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FORESTRY RESEARCH PROGRESS IN 1968

McINTIRE-STENNIS COOPERATIVE FORESTRY RESEARCH PROGRAM

COOPERATIVE STATE RESEARCH SERVICE

U.S. DEPARTMENT OF AGRICULTURE

Preface

The 1968 Annual Report of McIntire-Stennis research is arranged quite similar to the 1967 report. The 469 projects are subdivided by subject matter and in each division about one fourth of the projects have some supporting narrative and, frequently, a photograph or chart. Additional projects in each subdivision are shown by title. Publications arising from these projects are listed at the end of each subdivision. Projects supported with narrative were selected to be certain that each cooperating institution had at least one of its projects featured with supporting narrative and photographs. Narrative descriptions were written by the project leaders in their 1968 CRIS Progress Reports and were not altered for inclusion here except to correct typographical errors.

The INTRODUCTION section features a review of ASCUFRO along with portraits of the Executive committee that was active during 1968. Dr. James Bethel, University of Washington, succeeded to the Presidency on January 1, 1969 and Dr. Keith Arnold, University of Michigan, assumed the Vice-Presidency following the usual biennial election. Dr. Arnold resigned this post in April and it was filled by Dr. John Zivnuska, University of California, Berkeley.

The printing costs for this report were borne by the Association of State College and University Forestry Research Organizations. Additional copies may be obtained by request to: Division of Information, Office of Management Services, U.S. Department of Agriculture, Washington, D.C. 20250.

Contents

	Page
Introduction	1
CHAPTER I. Forest Resource Management	7
Remote Sensing Research (P.E. 624)	7
Remote Sensing (RPA 113)	7
Soil and Water Conservation (P.E. 685)	9
Soil Resources (RPA 101)	9
Soil Structure, Nutrients (RPA 102)	11
Uses of Land (RPA 104)	14
Watershed Development (P.E. 687)	14
Technology and Management (RPA 107)	14
Multiple Use and Programs (RPA 903)	17
CHAPTER II. Forest Resource Protection	19
Fire Prevention and Suppression Research (P.E. 689)	19
Forest Fires (RPA 203)	19
Forest Insect and Disease Research (P.E. 691)	20
Forest Insects (RPA 201)	20
Diseases of Forest Trees (RPA 202)	25
CHAPTER III. Forest Production	32
Production Efficiency Research (P.E. 612)	32
Range Management (RPA 112)	32
Timber Production Research (P.E. 693)	34
Forest and Range Resources (RPA 110)	34
Timber Management (RPA 111)	38
Biological Efficiency of Trees (RPA 301)	50
Engineering Systems (RPA 302)	65
Economics of Production (RPA 303)	66

	Page
CHAPTER IV. Forest Products and Marketing	68
Housing Research (P.E. 669)	68
Housing Needs (RPA 801)	68
Forest Products Marketing Research (P.E. 695)	70
Marketing Efficiency (RPA 502)	70
Grades and Standards (RPA 512)	72
Supply, Demand, and Price (RPA 513)	73
Forest Products Utilization Research (P.E. 697)	76
New and Improved Products (RPA 401)	76
CHAPTER V. Forest Recreation, Wildlife, and Natural Beauty	86
Outdoor Recreation Research (P.E. 698)	86
Forestland Recreation (RPA 902)	86
Wildlife and Fish Research (P.E. 699)	91
Biology and Habitat (RPA 904)	91
APPENDIX	98
Listing of Projects and Project Leaders	100

FORESTRY RESEARCH PROGRESS IN 1968

McIntire-Stennis Cooperative Forestry Research Program

Introduction

The McIntire-Stennis Cooperative Federal-State Forestry Research Program progressed through its fifth year of existence in 1968. From the vast pool of forest scientists in the states, some 460 were actively engaged on the 469 projects funded through the McIntire-Stennis Act (P.L. 87-788). In addition, the 442 graduate students partially or entirely subsidized by McIntire-Stennis funds materially increases the number of future forest scientists to satisfy the demand of universities, public agencies, and private industry.

An assessment has recently been made to estimate the numbers of students who have worked on McIntire-Stennis projects and who have graduated or otherwise reached the employment market. The results shown in Table 1 were compiled from estimates made at each cooperating institution and are arrayed in some general employment categories.

Table 1. Census of former graduate students who worked on McIntire-Stennis research projects

Employer	Nature of Employment				
	Teaching	Research & Development	Sales or Management	Others	Total
	<i>Number of McIntire-Stennis students</i>				
Federal	1	61	23		85
State	11	18	13	1	43
Private industry	0	28	36		64
International	4	11	4	2	21
Military service	4	9	9	30	52
University	51	32			83
Advanced studies	4	55	2	19	80
Others	5	7	3	1	16
Total	80	221	90	53	444

Compiled and edited by Dr. John D. Sullivan, Cooperative State Research Service, USDA, Washington, D.C. 20250.

Cover Picture: Bridge on Middle Fork of Willamette River, Courtesy of U.S. Forest Service.

It is interesting to note that almost 70 percent of these former students are involved in scientific endeavors, which is evidence of the value of research to the graduate learning experience.

Universities and various Federal agencies are the largest employers of McIntire-Stennis students. An almost equal number continue their academic experience at a more advanced graduate level. The Departments of Agriculture and Interior are the largest employers among the Federal agencies.

The year 1968 has been a pivotal one for the McIntire-Stennis Program because it marks the attainment of a certain maturity in its many projects. The reasons for this are individual to each participating institution, but several factors may be cited as characteristic of the nationwide program. First, the scientists have themselves matured. A number of new faculty positions were made possible by the McIntire-Stennis legislation and the positions were filled mostly at the Assistant Professor level by highly trained and basic science-oriented personnel. The application of their scientific expertise to the solution of forestry problems is now becoming apparent. A second common factor has been the assignment of McIntire-Stennis funds to faculty scientists who had previously been engaged primarily in teaching. For many, this has been their first opportunity to conduct research on a continuing basis that is not fragmented by the goals of their graduate students. A number of imaginative and fruitful projects, pertinent to the time and to the problems, have begun to emerge. Finally, the sustaining nature of the funds has permitted, in the universities, a program approach to forestry problems that coincides with the appearance of program-oriented national plans for agricultural and forestry research. Thus, many McIntire-Stennis research projects are important portions of larger research programs.

This relationship has become so prevalent that the 1968 progress report is subdivided by program and problem objectives rather than by forestry subject matter disciplines as in past progress reports. Table I, Appendix, shows the cross-over between research problem areas and subject matter disciplines. These are not intended to be exclusive relationships; pollution alleviation research, for example, could well appear in subject matter disciplines other than pathology. In this report, research problem areas are grouped, by relationship of objectives, into larger program elements to coincide with those of Agriculture 2000 as elucidated in the Program Planning and Budgeting System. Table II, Appendix, illustrates the relationship in Research Problem Areas between the National Program of Research for Forestry and the PPBS classification. Table III, Appendix, summarizes the projects, number of graduate students, current publications, and the number of scientists for each participating institution.

ASSOCIATION OF STATE COLLEGE AND UNIVERSITY FORESTRY RESEARCH ORGANIZATIONS

The McIntire-Stennis program owes much of its early history and later growth to the Association of State College and University Forestry Research Organizations (ASCUFRO), and its predecessor, The Commission on Forestry (COF). ASCUFRO and the McIntire-Stennis program are closely associated since institutional membership in ASCUFRO is based on certification of eligibility for McIntire-Stennis support under P.L. 87-788. Prior to the creation of COF and ASCUFRO, the question of Federal forestry research funds in State institutions was the responsibility of the Experiment Station Committee on Policy (ESCOP). Through an agreement between ESCOP and ASCUFRO, which was updated in November 1968, ASCUFRO assumed major responsibility for development of the McIntire-Stennis program. Dr. R. H. Westveld of Missouri was President of COF during the several years of its existence.

Dr. R. J. Preston, North Carolina State University, served ASCUFRO as its first President to be succeeded by Dr. Frank Kaufert, University of Minnesota, and, after January 1969, by Dr. James Bethel, University of Washington. Dr. R. M. Kallander of Oregon State University has been continuously active functioning as Secretary-Treasurer for ASCUFRO as well as for COF. Membership in ASCUFRO is open to either the administrative head or the Forestry Representative at any college or university certified to receive McIntire-Stennis funds. Members are

grouped into six geographical divisions headed by an elected chairman who is also then a member of the Executive Committee of ASCUFRO. Each Regional Committee meets at least once a year for the primary function of encouraging regional cooperation in the conduct of forestry research. In addition, matters of policy and procedure that concern members or regions are formulated for action by the Association, which meets once each year, usually just preceeding the annual SAF meeting. The Executive Committee, consisting of the Association President, Vice President, and the six chairmen of Regional Committees, functions in (1) developing information on existing research programs and on the needs for future research in the individual member institutions, (2) pointing out Federal policies and procedures that will implement support for member research programs, and (3) developing justification statements in support of appropriations requests and in supporting these programs in testimony to the USDA, the Bureau of the Budget, and to the Appropriations Subcommittee for Agriculture in the U.S. House of Representatives and the U.S. Senate.

The Association President, in addition to acting as chairman of the Executive Committee, bears responsibility for close liaison with the Cooperative Forestry Research Advisory Board and Advisory Committee, with CSRS, with the Experiment Station Committee on Organization and Policy, and, finally, with other Federal agencies that operate forestry research programs or that subsidize forestry research. ASCUFRO is clearly more than just a name and the representatives of member institutions speak for the forestry programs of their respective institutions.

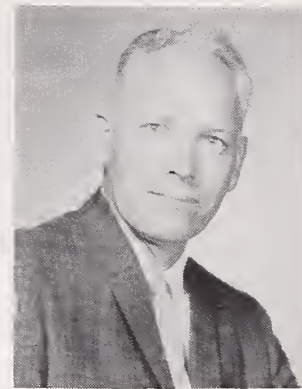
The officers and Executive Committee of ASCUFRO during the period covered by this report are shown in the accompanying photographs along with the states and institutions in each region.



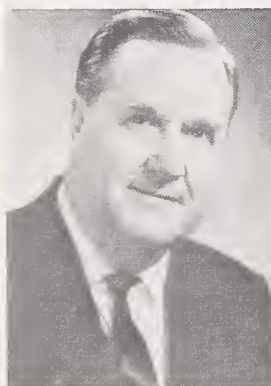
ASCUFRO PRESIDENT
Dr. Frank Kaufert
University of Minnesota



ASCUFRO VICE-PRESIDENT
Dr. James Bethel
University of Washington



SECRETARY-TREASURER
Dr. Rudy Kallander
Oregon State University



Professor Lloyd P. Blackwell, Louisiana Polytechnic Institute, Chairman of South Central Region.

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University of Arkansas
University of Kentucky
Louisiana State University
Louisiana Polytechnic Institute

Mississippi State University
Oklahoma State University
University of Tennessee
Texas A&M University



Dr. Donald P. Duncan, University of Missouri, Chairman of North Central Region

Southern Illinois University
University of Illinois
Purdue University
Iowa State University
University of Michigan
Michigan State University

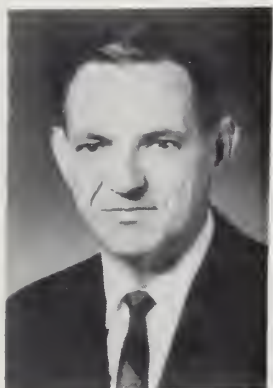
Michigan Technological University
University of Minnesota
University of Missouri
Ohio State University
University of Wisconsin



Dr. J. Whitney Floyd, Utah State University, Chairman, West Central Region

Arizona State University
Northern Arizona University
Colorado State University
University of Idaho
Kansas State University
Montana State University
University of Montana

University of Nebraska
New Mexico State University
North Dakota State University
South Dakota State University
Utah State University
University of Wyoming



Director John L. Gray, University of Florida, Chairman, Southern Region

University of Florida
University of Georgia
North Carolina State University

University of Puerto Rico
Clemson University
Virginia Polytechnic Institute



Mr. R. M. Kallander, Oregon State University, Chairman, Western Region

University of Alaska
University of California
Humboldt State College
University of Hawaii

University of Nevada
Oregon State University
Washington State University
University of Washington



Professor Arnold Rhodes, University of Massachusetts, Chairman, Northeast Region

Connecticut Agricultural
Experiment Station
University of Connecticut
University of Delaware
University of Maine
University of Maryland
University of Massachusetts
University of New Hampshire

Rutgers University
Cornell University
New York State University
Pennsylvania State University
University of Rhode Island
University of Vermont
West Virginia University

Chapter I

FOREST RESOURCE MANAGEMENT

Remote Sensing Research

Program Element 624

Reflected and emitted electromagnetic radiation from objects often contains information that characterizes one or more factors of the object. The interception and recording of such radiation data is referred to as remote sensing. The potential use of very high altitude scanning devices made possible by the U.S. satellite program offers an exciting prospect for large scale research on forestry problems.

REMOTE SENSING

Research Problem Area 113.

With one notable exception, current forestry research in remote sensing is closer to the ground than the satellite program and is devoted to the application of aerial photogrammetric techniques to forest resource problems.

University of CALIFORNIA 2180

Multiband spectral reconnaissance for forestry.

R. N. Colwell

Black-and-white aerial photography was obtained of forest and rangeland areas in California and Arizona in a large number of spectral bands and at scales ranging from 1/3,000 to 1/50,000. (Figure 1) For each area, and for the various film-filter scale combinations, interpreted both individually and in concert, quantitative determinations were made of the ease and accuracy with which timber and forage species

could be identified. In most instances, maximum information could be obtained through the joint use of three film-filter combinations: (1) panchromatic-25A (2) panchromatic-58 (3) Infrared-89B. Full color images were produced through simultaneous registration of these three types; (1) by simultaneous projection of the conjugate images in lantern slide form through three lantern slide projectors, each equipped with a filter of a different color, and (2) by simultaneous scanning of the conjugate images with closed-circuit color television cameras that activated the blue, green and red phosphors, respectively, on a color television screen. Attempts were made to identify timber and browse species on the various color composites. By checking these interpretations against "ground truth", accuracy determinations were made. Based on these findings, in March 1969, black-and-white multiband photography of our forest and range test sites in Arizona will be taken to our specifications from earth orbit by the Apollo 9 astronauts. We are charged by NASA with making detailed interpretations of that space photography in various color combined forms.



Figure 1. At Glacier Point in Yosemite Valley research workers of the School of Forestry and Conservation, University of California, take multiband photographs and thermograms of forest test areas on the floor of Yosemite Valley, more than 3,000 feet below. In the view seen here, interested sightseers intermingle with the researchers. University of California - Berkeley 2180.

ADDITIONAL PROJECTS

University of ARIZONA 662

Development of volume tables for ponderosa pine from aerial photos.

G. S. Lehman

University of MASSACHUSETTS 8

Aerial photographs to evaluate the recreational resources of a river.

W. P. MacConnell

University of MONTANA 1610

Photo-interpretation of the forest industry.

W. R. Pierce

NEW YORK - Cornell University 906

Classification of rural lands based on remote sensor surveys.

L. S. Hamilton and E. Hardy

OREGON State University F-843

Prediction of growth and yield of young-growth Douglas-fir stands.

D. P. Paine

PUBLICATIONS

Belcher, D., et. al.

1968 *Potential benefits to be derived from applications of remote sensing of agricultural, forest, and range resources.* Cornell Univ., Ithaca, N.Y.

Carneggie, D. M., et. al.

More on false-color film. Jour. Forestry 60
1968 (11) 864.

Colwell, R. N.

Remote sensing of natural resources. Scien-
1968 tific American 218 (1) 54-69.

Lauer, D. T.

*Forest species identification and timber type
1968 delineation on multispectral photography.*
Annual Progress Report to NASA, OSSA,
dated 30 September, 1968. 85.

Soil and Water Conservation and Development Research

Program Element 685

Forestry research in this program element is aimed at providing information for the wise management of soil and water resources at a time when urban water requirements bring ever increasing pressure on these resources now allotted to forestry and agriculture. Massive urban development removes vegetation from land areas resulting in intensified problems of runoff, water control, and waste management.

APPRAISAL OF SOIL RESOURCES

Research Problem Area 101.

In this problem area, forest soil resources are characterized by profile description; physical, chemical, and mineralogical properties; moisture relations; slope; and degree of erosion potential. Information developed by this research will provide basic planning data to determine conservation needs and land use practices for forestry and agriculture, and for non-agricultural functions.

Northern ARIZONA University 3

*Past vegetation and climates of Ponderosa pine zone
in Northern Arizona.* D. W. Berry

Work on this project has been concentrated on the Walker Lake sediments. Slides have been prepared at five-centimeter intervals to a depth of 7.30 meters. Analysis of slides from the five-centimeter sample is complete from 3.67 meters to 4.97 meters for core "A". Contrary to earlier estimates, the results of this partial analysis indicate that it will not be necessary to intensify the sampling to one-centimeter intervals. A preliminary pollen profile, prepared from the material analyzed to date, indicates that several pollen species can be used as keys to climatic changes. Pollen frequencies for 5-centimeter samples are shown in Figure 2. Totally unexpected was the

extremely high percentage of artemisia present in the levels examined so far, particularly since surface materials yield considerably less than 1% artemisia. Analysis of the remaining slides is in progress.

University of HAWAII 140

*Forest floors and soils in some introduced and
indigenous forests of Hawaii.*

L. D. Swindale and Y. W. Tamimi

Through the ages, mineral recycling by plant and animal life has been a major factor in soil formation and plant adaptation. Scientists are investigating magnitudes of trees and grasses and their role in mineral recycling. One of the main interests of the studies carried on by the University of Hawaii in this line is to determine the magnitude of mineral recycling by two endemic and two exotic timber species. Koa and ohia are the endemic species while flooded gum (*Eucalyptus saligna*) and Australian red cedar are the exotic species.

Falling leaves and branches (litter), water running down tree stems (stem flow), rain water dripping from leaves (through fall), and rainfall water are collected monthly from stands of the above mentioned species (Figure 3). Samples collected are processed and chemically analyzed for several elements.

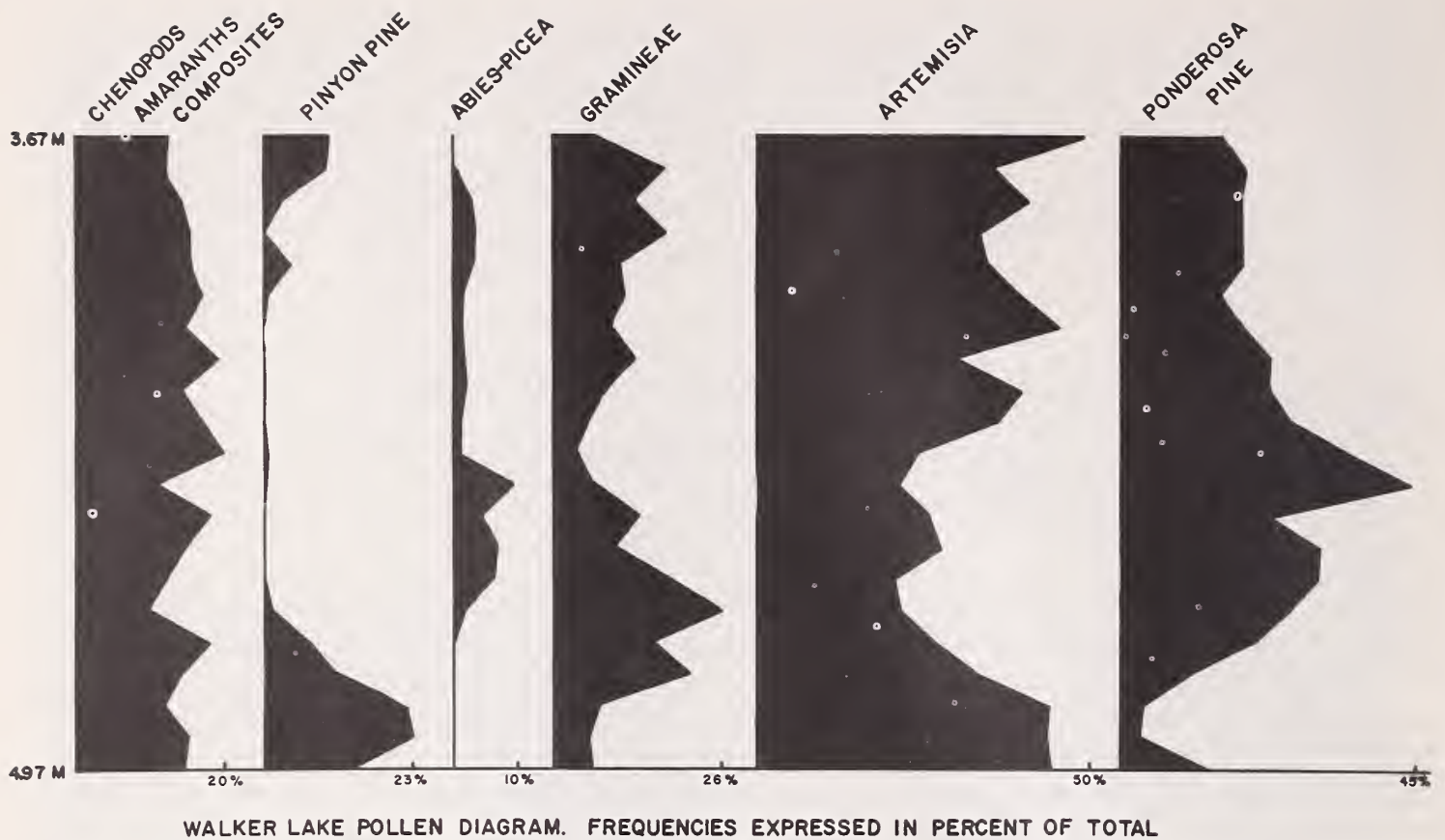


Figure 2. Pollen frequencies for 5-centimeter samples showing the high percentage of *Artemisia* present. Northern Arizona University 3.



Figure 3. Australian red cedar stand with litter collection tray in the foreground, stem flow collection (center), leaf through fall catchment (right hand side). University of Hawaii 140.

During the initial four-month's period of this study it was found that koa contributed the highest amount of phosphorus per acre (305 grams) followed by flooded gum (237 grams), Australian red cedar (209 grams) and the least by ohia (13 grams). Potassium was recycled in this decreasing order of contribution per acre: Australian red cedar (4135 grams), koa (2049 grams), flooded gum (1802 grams) and ohia (1039 grams).

Flooded gum in this period of 4 months contributed 12,435 grams of calcium per acre followed by ohia (6850 grams), koa (6631 grams), Australian red cedar (4372 grams). Another element of importance is magnesium. Flooded gum had the highest contribution, (1348 grams/acre), followed by koa (1160 grams/acre), ohia (1008 grams/acre) and, least by Australian red cedar (475 grams/acre). The nature and amount of recycled elements have a great effect upon building up or deteriorating the soil, chemically and physically. Elements such as calcium normally contribute greatly to stabilizing soil aggregates thus allowing better soil conditions for good drainage.

Data presented above cover a relatively short period of time for this type of study. It will take at least three years of collection in order to reach some conclusions. Another phase of study under this project is to correlate several soil physical and chemical conditions with productivity of 30 year old stands of Australian red cedar found on several islands. Data collected and analyses conducted during the last two years from a total of thirteen sites are now undergoing statistical analysis for interpretations.

Moisture, depth, physical and chemical conditions of soils have a great influence on root development and tree growth. To evaluate the effects of the above mentioned factors on root growth of tropical species, new series of experiments are being initiated.

ADDITIONAL PROJECTS

CONNECTICUT - New Haven 411

Phosphorus in lake sediments.

R. D. Harter

University of CONNECTICUT 390

The role of the forest in open-space planning in Eastern Connecticut.

M. J. Gratzner and R. D. McDowell

University of MISSOURI 522

Energy and water balance of forest and range sites.

G. S. Cox

PUBLICATIONS

Harter, R. D.

Adsorption of phosphorus by lake sediments.

1968 Soil Sci. Soc. Amer. Proc. 32: 514-518.

SOIL STRUCTURE; SOIL, PLANT, AND WATER NUTRIENT RELATIONSHIPS

Research Problem Area 102

Research studies provide information on which to base management procedures to develop and maintain structural conditions favoring air and water movement and penetration of tree and other plant roots. Studies are also in progress on the rate and manner of fertilizer application and on the biochemical processes that regulate nutrient retention and availability in trees.

CALIFORNIA - Humboldt State College 3

Soil-water-vegetation relations in Douglas-fir zone.

D. J. Jader

A pilot calibration of the Elder Creek watershed in Mendocino County, California, resulted in the establishment of two permanent weather stations, the design of a storage rain gauge for sampling rainfall in the remote sections of the watershed, and the establishment of three soil moisture plots to be used to design a future soil moisture sampling technique using the nuclear method. Such a high correlation was found between the precipitation data of the two weather stations, it was concluded that the recording rain gauge at the more inaccessible station could be removed. The storage gauge design was found acceptable if additional attention was given to protect them from animal damage. Random sampling was found acceptable to determine soil moisture within designated soil vegetation types. From the variability found in this study, a sample size of seven tubes would provide an estimate of the soil moisture within 10 percent at a confidence level of 90 percent. At the same level of confidence, a sample size of 10 tubes would be necessary to detect differences in soil moisture between sample areas. The work has been completed and the project is now terminated.

Hardwood planting on strip mined lands.

W. A. Geyer

A series of planting trials were begun to compare planting soft maple (Figure 4) and cottonwood at 8 and 15 inch depths on types of fresh spoils on unleveled and partially leveled banks. Moisture was adequate. Survival of silver maple and cottonwood seedlings was 87 and 64% at either planting depth; for cottonwood cuttings 8 and 24% at 8 and 15 inch depth respectively. Leveling did not affect survival. Planting depth did not affect new height. The average new growth was 25 for cottonwood cuttings and 12 for cottonwood and 10 inches for silver maple seedlings. Growth on the leveled spoils was reduced about 43%. Second growing season data indicate little change in species survival; growth of cottonwood continues better than silver maple.

Eight species were planted the next year. Cottonwood and silver maple survival was 70%. Autumn olive, bald cypress, black alder and osage orange was



Figure 4. Excellent second year silver maple seedlings on east slope of clayey spoil banks. Numerous stems typical of this species. Kansas State University 721.

less. Loblolly and jack pine and cottonwood cutting survival was poor. Plantings will be continued. Numerous cottonwood clones as well as sycamore will be outplanted.

University of NEBRASKA 20-23

Windbreak Shelter Effects.

W. T. Bagley and N. J. Rosenberg

Uniformity trials are continuing using wheat as a crop on a 232-acre windbreak complex at the University of Nebraska Field Laboratory, Mead. Crop response is providing a good measure of site differences among the 511 subplots. As the trees grow and the windbreaks become effective in reducing wind velocity, crop yields will measure windbreak influence. Subplots are harvested by combine. Gross weights are obtained on a portable field scale and corrected for moisture content as shown in Figure 5.



Figure 5. Weighing wheat harvested by combine from a one-half acre sub-plot. 511 of these plots were harvested each year to determine the effect of windbreak protection on crop yield. University of Nebraska 20-23.

NORTH DAKOTA State University 12-1

Establishment, maintenance, and effects of shelterbelt in North Dakota.

E. P. Lana

Studies were started to determine the best cultural practices for the establishment of trees of various sizes in the prairie area (public use, shelterbelts, etc.).

Treatments include polyethylene mulch, cultivation and watering. Tree sizes range from 1-0 seedlings inches in height to trees eight feet tall. Two of three sites were planted in 1968; a third is planned for 1969. New growth and survival data of ponderosa pine seedlings were taken in October. New growth was significant at the 5% level for the three treatments compared to control. No significance was found among the treatments. Studies have been initiated to evaluate the long range impact of soil treatments on mycorrhizal development. A study on the biology of the Cotoneaster webworm has been completed. Some progress has been made on the distribution of the elm sawfly eggs and cocoons. This should ultimately lead to a better understanding of the sporadic nature of outbreaks of this pest in willow shelterbelts. Test on biological control of cankerworm with *Bacillus thuringiensis* (Berl.) were conducted with the US Forest Service. The influence of removal of herbaceous understory vegetation on soil moisture and tree growth in shelterbelts in the Red River Valley was begun in 1968. Soil moisture and height and diameter measurements of tree species were made in the cultivated and uncultivated plots. Depth measurements and water content of snow drifts will be determined. Preliminary results indicate soil moisture already is greater in cultivated segments of the shelterbelts.

ADDITIONAL PROJECTS

University of ARIZONA 636

Nitrogen and carbon balances in forest and range ecosystems in Arizona. J. O. Klemmedson

CONNECTICUT - New Haven 415

Waste water renovation potential of forest soils. D. E. Hill and P. E. Waggoner

University of HAWAII 139

Fertilization and culture of Hawaii tree crops. Y. W. Tamimi

KANSAS State University 668

Windbreak influences. W. A. Geyer

University of KENTUCKY 194

Cation and anion uptake by plant roots. A. J. Hiatt

UTAH State University 670

Range plant foliage removal effects on soil moisture regime. G. B. Coltharp

University of WASHINGTON 12

Influence of fire on forest soils. D. W. Cole

University of WASHINGTON 17

Pedological investigation of forest soils. F. C. Ugolini

WASHINGTON State University 1925

Ecologic characteristics of elk sedge for erosion control. B. F. Roche, Jr.

PUBLICATIONS

Brown, K. W. and N. J. Rosenberg.
Errors in sampling and infrared analysis of CO² in air and their influence in determination of net photosynthetic rate. Agron. Jour. 60: 309-311.

Buckhouse, J. C.
Effects of range plant foliage removal on soil moisture regime at two elevations in central Utah. M.S. Thesis, Utah State University.

Buckhouse, J. C. and G. B. Coltharp.
Effects of simulated grazing on soil moisture content in mid-elevation reseeded rangeland. Proc. Utah Acad. Sci., Arts, and Letters, Vol. 45, Part 1.

Hill, D. E. and B. L. Sawhney.
Electron probe microanalysis of thin sections of soils to observe loci of cation exchange. Agron. Abstracts, 172. Am. Soc. of Agron. Madison, Wisconsin.

Liddle, J. L.
Effects of herbicides on tree growth, tree condition and weed control in shelterbelts. M.S. Thesis, Univ. of Nebraska. May 1968, 53 pp.

Richards, D. L.
Pilot calibration of the Elder Creek watershed. M.S. Thesis, Humboldt State College, Arcata, California.

Roth, P. L.

1968 *Ecological factors affecting survival and performance of tree species in Kansas shelterbelts*. Ph.D. Dissertation, Kans. State Univ., Manhattan, Kansas. 107 pp.

ALTERNATIVE USES OF LAND

Research Problem Area 104.

Research attention is devoted to analysis of the economic effects of alternative proposals for guiding land development as urban uses extend into rural areas. A great portion of forestry research in Problem Areas 107, 902, 903, 110, and 111 bear on alternative uses of land.

NEW YORK - Cornell University 908

Susceptibility of absentee forest landowners to forestry education. A. Dickson

So far, pertinent literature has been reviewed and tax rolls and cooperator lists of appropriate government

agencies in the three southwestern counties of New York—Chautauqua, Cattaraugus and Allegany—have been used for a preliminary selection of eligible owners. The final selection of some 300 will be interviewed to obtain the desired information. In addition, the rationale behind present public forestry information programs will be obtained through consultation with the sponsoring agencies. Field inspection will be used to check “management” where deemed necessary or advisable.

ADDITIONAL PROJECTS

CALIFORNIA - Humboldt State College 13

The optimum mix of undeveloped and developed land within a hyleopolis. E. W. Pierson

PUBLICATIONS

None

Watershed Development Research

Program Element 687

Research in this area is conducted to improve our capability of using and managing all watershed lands to assure needed forest products with minimum erosion and sedimentation, to supply reliable quantities of high quality water, and to develop legal and institutional arrangements essential to watershed development.

TECHNOLOGY OF WATERSHED CONSERVATION AND MANAGEMENT

Research Problem Area 107.

The use of mathematical relationships that describe the hydrologic influence of vegetative and land use changes on water yield is covered by research in forestry. Another critical area is economic research to determine the value of water in alternative uses to provide a basis for resource allocation.

COLORADO State University 316

Effects of fire on hydrology and erosion.

W. D. Striffler

During the summer of 1967, 20 erosion plots and 50 soil sampling points were established in the Comanche Burn area, a 600 acre burn in the Central Rocky

Mountains. Observations indicate that erosion during the first summer following the burn was not a serious problem but that some erosion was occurring. Studies using tagged soil particles (both dyes and isotopes) show that rain drop splash on the bare soil surface is the motivating force and soil particle movement is largely confined to micro-channel systems downslope from the plots. The results indicated that the amount of rock exposed on the soil surface was more important than slope in initiating particle movement during low intensity storms. Analysis of soil physical factors show that the burn had very little effect in spite of a complete destruction of litter and surface vegetation. This was attributed to the coarse textured soils occupying the area.

This project was terminated.

Data reduction methods for streamflow from small wildland watersheds.
G. E. Hart

A simple semi-automatic technique has been developed for transcribing the essential elements of an analog strip-chart streamflow recorder into digital form for computer integration into flow volumes. The volume of flow is calculated for months, days, and variable intervals within each day. The output is in punched cards and on printed sheets.

The long-term yields from two small drainages with north and southwest aspects in the Davis County Experimental Watershed have been determined for a 22 year period. Annual yield averaged 18 inches and ranged from 8 to 32 inches; mean precipitation was 42 inches with a low of 31 and a high of 51 inches. As expected, the maximum yield occurred from snowmelt runoff in May. But the yields in September and October were surprisingly high, approximately 0.6 inch per month in spite of a generally low rainfall, about 1 1/2 inch per month. In this area of highly fractured bedrock, the relatively high summer yields



Figure 6. Project leader G. E. Hart demonstrates the interpretation problem for data reduction for streamflow. Utah State University 733.

suggest the possible contribution of sustained deep-seepage flow from outside these drainages.

Two periods have been selected for more detailed study of the relationships between streamflow, climate and vegetation. In the snowmelt period, peak snow accumulation and degree-day factors will be tested; in the low-flow period moisture depletion, precipitation, and vegetational distribution will be examined. Data are shown in figure 6.

WASHINGTON State University 1913

Watershed disturbance by tractor skidding.
D. R. Satterlund

Field work in this study has been essentially completed and analysis of the data is well underway.

Preliminary indications are that soil exposure and disturbance by crawler tractors is about twice that caused by rubber-tired skidders in several partial cuts in the spruce-fir type (Figure 7) on moderate slopes. However, total disturbance is not great in either case. Further observations indicate that litter accumulation and subsidiary vegetation recovery on logged areas is rapid, and that soil disturbance during and after logging is probably of minor importance in partial cutting operations of this type.



Figure 7. Mixed-conifer stand showing disturbance from logging operation. Washington State University 1913.

ADDITIONAL PROJECTS

University of ARIZONA 631

Snow water yield from conifer forest. D. B. Thorud

COLORADO State University 312

Land use and water quality on forested mountain watershed. J. R. Meiman

CONNECTICUT - New Haven 408

Conserving soil moisture with a stomata-closing chemical. P. E. Waggoner

University of MASSACHUSETTS 2

Evapotranspiration, run-off, storage, and drainage characteristics of forest soils. D. L. Mader

PENNSYLVANIA State University 1495

Influence of timber harvesting methods from small watersheds. W. E. Sopper,
R. E. Melton, P. W. Fletcher

UTAH State University 641

Management of aspen and water yields. J. D. Schultz

University of WASHINGTON 11

Water retention by foliage of tree branches.
S. P. Gessel and D. D. Wooldridge

University of WASHINGTON 20

Quantity measurements of snow-melt as related to run-off. D. D. Wooldridge and S. P. Gessel

WASHINGTON State University 1849

Snow catch in coniferous crowns D. R. Satterlund

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MULTIPLE USE POTENTIAL OF FOREST LAND AND EVALUATION OF FORESTRY PROGRAMS

Research Problem Area 903

Research on multiple use of forested lands progresses along two parallel paths: determination of the biological compatibility of possible multiple uses of forest land, and the economic evaluation of relative costs and returns for combinations of use and land treatments on public and private land.

University of MONTANA 2001

Evaluating forest resource multiple use.

W. K. Gibson

All basic resource data has been collected. Two timber types have been analyzed on the computer. The remaining three timber types have been key punched and are ready to be run. Grazing use is ready to be added to the timber combination and is ready for key punching. The recreation option is currently being formulated. It is anticipated that the combining of use alternatives will be accomplished in the next 6 months.

NEW JERSEY - Rutgers University 256

Evaluation of the multiple uses of New Jersey's public forest land resources. R. F. West and R. Rogers

Analyses of data obtained in survey of hikers using the Appalachian Trail in Stokes State Forest during the summer and fall of 1967 provided considerable information regarding the characteristics of the hikers and differences between organized and unorganized groups, summer and fall, and weekday and weekend use. Some of the greatest frequencies in combined summer and fall concerned the unorganized hiker: 75% with family or friends, 81% over weekends, 75% less than 60 miles from home, 42% professional employment. A rather typical interview is shown in Figure 8. There were 3:1 males, average salary \$9300, average hike was 20 miles in 2 1/2 days. Hikers were mostly experienced and motivated both by personal interest in outdoors and previous experience in organized groups. They spent an average 7 1/2 days and 17% of their vacation time in hiking.

All of the analyses on the timber, growth and vegetative inventory of the 12,200-acre Stokes State

Forest in New Jersey were completed. Cover type maps were prepared by using the computer mapping technique. Timber density and understory cover maps were also prepared to be used as overlays. The mortality of trees was determined and incidence and insect damage was mapped. This comprehensive inventory will provide valuable information needed by the State in formulating and projecting plans for expansion of multiple uses in Stokes Forest and evaluation of these uses.

ADDITIONAL PROJECTS

University of ARKANSAS 610

Use alternatives on forest lands of the Ozark Upland Region of North Arkansas.

F. M. Meade

Southern ILLINOIS 65-R-13

Taxation of multiple-use forest land.

R. I. Beazley

INDIANA - Purdue University 1354

Management of outdoor recreation resources.

D. M. Knudson

University of MISSOURI 617

Assistance programs on private forestry.

J. M. Nichols

University of MONTANA 205

Montana forest property taxing procedure.

W. K. Gibson

University of MONTANA 603

Grazing use and forage yield of forest land in Western Montana.

M. S. Morris and L. Eddleman

University of RHODE ISLAND 125

Development of Rhode Island forested lands.

C. Gratto

University of TENNESSEE 10

Economics of alternative timber-growing practices in Tennessee hardwood stands.

G. R. Wells



Figure 8. Hikers (father and son) being interviewed on Appalachian Trail. Rutgers University 256.

University of VERMONT 6

Economics of multiple use of forested land.

F. O. Sargent

University of WASHINGTON 3

Recreational uses of forest lands.

G. W. Sharpe

University of WASHINGTON 21

A systems approach to the analysis of a coniferous ecosystem.

D. W. Cole

WASHINGTON State University 1848

Guidelines for recreation in multiple use land management.

M. Mosher and C. D. Mattson

University of WISCONSIN 1571

Computer simulation of sampling designs and management practices in forestry.

L. G. Arvanitis

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Chapter 2

FOREST RESOURCE PROTECTION

Fire Prevention and Suppression Research

Program Element 689

Continuing research on forest fire prevention and control is imperative as progressively more people make use of forest resources and as intensive management increases the values of trees and forest land. Rapid control of forest fires can significantly reduce the drain on these natural resources and on public funds.

PREVENTION AND CONTROL OF FOREST FIRES

Research Problem Area 203.

Fire research in the universities is frequently involved with the effects of fire on biological communities and on reclamation of burned-over land and may be classified in Research Problem Areas 102, 107, 111, and 904.

University of CALIFORNIA - Berkeley 2351

Relation of composition and distribution of vegetation to fuels on wildlands. A. M. Schultz

Information theory gives a sensitive measure for taxonomic variety and for spatial distribution of individuals, but it becomes less sensitive for growth forms and fuel types. In grasslands, individual plants

cannot be determined with certainty; moreover, annual grasses have essentially identical fuel properties. In pure chaparral stands, information in the system is low due to redundancy. As brush stands become more mixed, species diversity increases more rapidly than variation in fuel type, and the spatial distribution measure goes down. In forests the potential three-dimensional structure, that is, additional height of the system, increases the information content, but when fuel considerations are brought in, there is no significant change. The present conclusion is that information theory cannot provide a useful index of fuel diversity.

ADDITIONAL PROJECTS

None

PUBLICATIONS

None

Forest Insect and Disease Research

Program Element 691

The control of forest diseases and insects is an unending problem to managers who must depend on research data to develop effective programs for reducing economic losses traceable to pathogens and insects. Increased research attention has been devoted to biological controls and to techniques for concentrating populations to make more effective use of chemical controls.

CONTROL OF FOREST INSECTS

Research Problem Area 201.

Forest insect research is active at 21 universities. Much emphasis is placed on population studies since this is essential for evaluation of control programs. Insect attractant research has already revealed some potentially powerful control tools, and current research on the biochemistry of insect toxins is paralleled by increased attention to insect physiology.

University of ARKANSAS 662

Control of insects affecting seed production of loblolly and shortleaf pines in Arkansas.

W. C. Yearian

Over 400 species of arthropods have been found associated with the cone-terminal complex of loblolly and short leaf pines in Arkansas. Of these, only 14 species of insects are considered significant in reducing pine seed production with the most important being *Dioryctria amatella*, *D. clarioralis*, *D. disclusa*, *D. n. sp.*, and *Laspeyresia ingens*. *Dioryctria* larvae burrow and feed in both 1st and 2nd year cones. *D. amatella* has 3 generations per year and feeds primarily on 2nd year cones. *D. clarioralis* also passes through 3 generations a year, but feeds on 2nd year cones the 1st and 2nd generations and on 1st year cones the 3rd generation. *D. disclusa* requires a year to complete its life cycle and the larvae have only been observed during the spring and early summer on 2nd year cones. *D. cisclusa* is restricted to loblolly pine. A new species of *Dioryctria* has also been collected, but its life and seasonal histories are unknown. Mean statewide damage, 1966-1968, for *Dioryctria* collectively was: loblolly pine 1st and 2nd year cones, 4% and 31%, respectively; and shortleaf 1st and 2nd year cones 2% and 9%, respectively.

The larvae of *Laspeyresia ingens* burrow in 2nd year cones and feed on the developing seeds as shown in fig. 9. *L. ingens* has one generation a year and overwinters as a larva in the cone axis. Seedworms damaged 8.5% and 1.4% of the loblolly and shortleaf cones, respectively, examined in 1967 and 1968.



Figure 9. *Laspeyresia ingens* feeding on seed in mature loblolly pine cone. University of Arkansas 662.

University of MARYLAND H-83

Loblolly pine cone insects.

W. E. Bickley and F. E. Wood

Detailed studies of eggs, larvae, pupal cases, wings, and male genitalia show that pine coneworms of the genus *Dioryctria* in Maryland differ from *zimmermani* and from *amatella* which has been studied in Florida, Georgia, and North Carolina. Maryland forms are rather constant. Eggs are slightly larger. Larvae eat cones and new growth in tips and not bark. Pupal cases are dark brown indicating lack of affinity with *zimmermani*. Differences in banding of the fore wings and dark areas of the hind wings have been recorded. Statistical analyses of some structures of the male

genitalia are in progress. Biology and morphology of the Maryland form suggests that it may be a subspecies of *amatella*. Further consideration of the use of systemic insecticides reveals impracticability.

University of MICHIGAN 2

Comparative natural histories of three closely related beetles of the Genus Agrilus. F. B. Knight

Field work on behavior and general biology was done in Iron Co., Michigan. *A. Horni* has a two year life cycle, infests aspen suckers of apparently normal vigor, and oviposits only on those within narrowly-defined diameter limits (0.3 to 0.9 inches at the base). The mode of host selection relies on a thigmotactic mechanism. *A. anxius* and *A. granulatus liragus* have a variable life cycle, one or two years, depending on host conditions. They infest trees in a decrepit physiological condition and adults seem to be attracted by this condition.

The behavior of adults was studied in field and laboratory. The meeting of sexes depends on the same factors which influenced host selection by females. Males recognize females only after making physical contact with them, and discriminate between females and other males only after direct contact. In the laboratory, males do not appear to distinguish conspecific females from other species.

The biological differences between *A. horni*, on the one hand, and *A. anxius* and *A. G. liragus* on the other, seems to be so great as to preclude the deviation of the one kind of biology from the other. The habits of *A. pensus* on alder appear much closer. *A. pensus* and *A. anxius* possibly diverged from a common ancestor during the pleistocene. A taxonomic study was completed on all four species. Other related forms were studied from specimens in the U.S. National Museum and the Philadelphia Academy of Natural Sciences. The *Agrilus anxius* group was defined and though its limits are uncertain, it appears to be worldwide in distribution.

NEW MEXICO State University 4

Seed and cone insects of forest trees.

H. G. Kinzer and J. G. Watts

Ponderosa pine in New Mexico was found to be attacked by fifteen species of insects damaging to

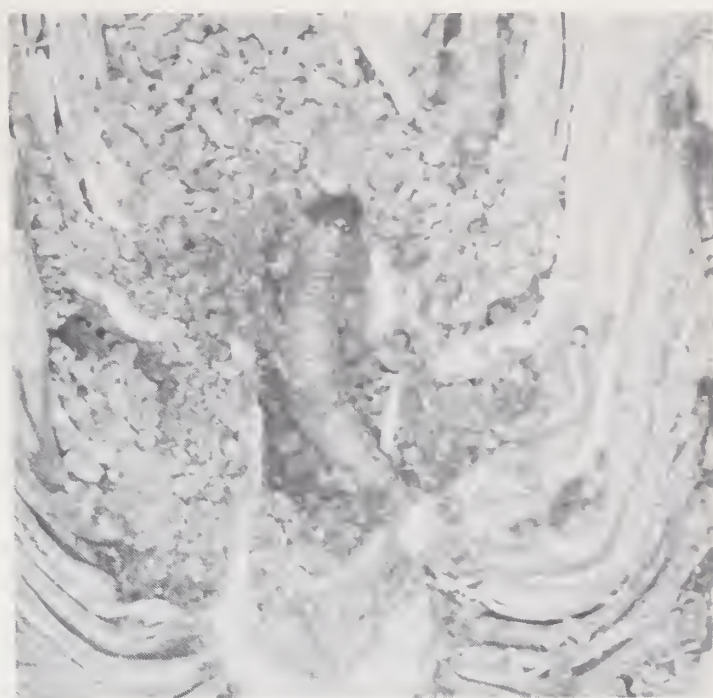


Figure 10. *Dioryctria auranticella* (Grote) completely destroying ponderosa pine cone. A three year damage survey indicated that this insect destroys approximately 8% of the ponderosa pine seed crop in southern New Mexico each year. New Mexico State University 4.

seeds or cones (fig. 10). An additional twenty-four cone-associated species cause no damage. Twenty-four parasitic species were reared from insect infested cones. Nine species of predaceous insects were found in association with ponderosa cones. Surveys of insect damage in two national forests showed that *Conophthorus ponderosa* (Hopk.) caused an average annual loss of 27.8% of the potential seed crop. *Megastigmus albifrons* (Walk.), *Laspeyresia piperana* (Kft.) and *Dioryctria auranticella* (Grote) caused an average loss of 15.6%, 5.9%, and 8.1%, respectively. Douglas-fir was infested with nineteen damaging and twelve non-damaging insect species. Twenty-one parasitic and two predaceous insects were reared from or found in association with Douglas-fir cones. *Barbara colfaxiana* (Kft.) and *Dioryctria abietella* (D&S) were the most damaging species. The number of insect species found in association with white fir, limber pine, engelmann spruce and pinon pine were 15, 12, 6, and 6, respectively. Studies of the characteristics of damage to the host, time of emergence of the overwintering forms, and time of oviposition or attack on the host were made for most damaging species. To date, this study has yielded at least thirty-four new insect records for ponderosa pine and twenty new insect records for Douglas-fir. Four new insect species and one new genus have been found on ponderosa pine and two new insect species

have been found on Douglas-fir. The final results will be analyzed and published when all insect identifications for the 1968 season are completed.

University of PUERTO RICO 2

Biology and control of the cedar shoot-borer.

L. F. Martorell

A new field experiment was established at the Gurabo Substation to determine the effectiveness of 8 insecticides against the shoot-borer, in which cedar, *Cedrela odorata*, was used as the host plant. The insecticides used were: DDT, Disyston, Cygon, Azodrin, Endrin, Fitos, Thorbidan, and Thimet, all in emulsion concentrates except Disyston which was applied in granular form as well. Four field counts at monthly intervals made from July to October showed ineffectiveness of the insecticides for control of the pest. As in previous trials, the insecticides have not been able to stop the moth-borer infestations (fig. 11) even in small seedlings from 1 to 3 feet in height. Examination of alternate host plants in the field and



Figure 11. Damaged area in base of terminal shoots of a Central American mahogany seedling resulting from the cedar shoot borer. University of Puerto Rico 2.

in the experimental plot planted at the Main Station at Rio Piedras (*Swietenia mahogany*, *Guarea guidonia*, *Melia azedarach*, *Guarea ramiflora*, *Trichilia hirta* and *Cedrela odorata*) showed the total absence of the insect in all of them, with the exception of *Cedrela* and *Swietenia*. Still *Cedrela* seems to be the preferred host of *Hypsipyla* in Puerto Rico.

ADDITIONAL PROJECTS

University of ARKANSAS 611

The control of pine sawflies in Arkansas with special reference to the use of biological control agents.

L. O. Warren and J. P. Fulton

University of ARKANSAS 656

Significance of Ips bark beetles and associated fungi causing death of pine in Arkansas.

W. C. Yearian and C. L. Wilson

COLORADO State University 318

Systemic insecticides in coniferous forest trees.

N. D. Wygant and R. E. Johnson

University of GEORGIA 18

Investigations of insects affecting pine cones and seeds in the Piedmont of Georgia.

R. T. Franklin

University of IDAHO 13

Bionomics and control of cone and seed insects.

J. A. Schenk

KANSAS State University 671

Entomology and windbreak tree species.

H. E. Thompson

University of MAINE 5007

Biology and control of the balsam gall midge.

E. A. Osgood and J. B. Dimond

University of MICHIGAN 14

Population regulation of beetles in aspen.

F. B. Knight

MICHIGAN State University 942

Autostability of arthropod component in plantation conifers.
J. A. Butcher

MICHIGAN Technological University 2-3013

Basic studies on the insect transmission of scleroderis canker.
N. F. Sloan

MISSISSIPPI State University 1129

Study of economic insects attacking certain forest tree seeds and forest seedlings.
W. W. Neel

University of MONTANA 1604

Spruce budworm defoliation in Douglas-fir.
J. H. Lowe

University of NEW HAMPSHIRE 4

The ecology of the oribated mites and springtails of the soils of the white pine cover type in New Hampshire.
R. M. Reeves

NEW MEXICO State University 7

Biology and host finding mechanism of the ponderosa pine cone beetle.
H. G. Kinzer and J. G. Watts

OHIO Agricultural Research and
Development Center 3

Integrated control of the insect and mite pests of pine trees.
R. L. Campbell

OKLAHOMA State University 1235

Bionomics, ecology, and control of the Nantucket pine tip moth.
R. D. Eikenbary

OREGON State University F-824

Biology of the Hemlock Hylesinus.
W. P. Nagel

PENNSYLVANIA State University 1750

Development of the Eastern spruce gall aphid and its control.
W. H. Kearby

University of PUERTO RICO 3

Ecological relationship, distribution, and control of two important species of arboreal termites.
L. F. Martorell

TEXAS A & M University 1525

Development of diets and rearing methods for Southern pine beetle.
P. L. Adkisson

TEXAS A & M University 1650

Evaluation of formosan termite in Texas.
A. E. Lund

University of WISCONSIN 1263

Population dynamics of sawflies associated with coniferous plantations.
D. M. Benjamin

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Wingfield, M. and L. O. Warren.

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CONTROL OF DISEASES OF FOREST TREES

Research Problem Area 202.

Forest tree research includes studies on possible biotic control mechanisms through organisms like bacteria, viruses, and nematodes. The problems of seeds and seedlings, and root, stem, and foliar diseases of forest trees are researched in 31 projects at 24 institutions.

University of FLORIDA 1320

Fusiform rust resistance in slash pine. R. A. Schmidt

Fusiform rust, caused by the fungus *Cronartium fusiforme*, is an important obstacle to the management of slash pine (*Pinus elliottii* var. *elliottii*) in the Southeastern U.S. This project seeks methods of screening large numbers of slash pine seedlings for resistance to *C. fusiforme*. Seedlings to be screened come mainly from progeny of slash pine selected for growth parameters; although a few progeny from parents selected for rust resistance are included.

The third yearly planting of 1-year-old seedlings was established in a "rust nursery" where oaks, between rows of pine, provide inoculum under near-normal field conditions (fig. 12). Evaluation of rust resistance



Figure 12. Satisfactory field conditions were obtained in this "rust nursery." University of Florida 1320.

will be made after each planting has been exposed for three years. Attempts to screen seedlings in modified greenhouse conditions were unsuccessful as only a small percentage of the cotyledon and 1-year-old pines developed rust galls. Following the success of other investigations, a "small screening shed," which will facilitate the provision of optimum environmental conditions, is being tested.

LOUISIANA Polytechnic Institute 5

The morphology and cytology of the pine-oak gall rusts in the South and the relationship with their coniferous and angiospermous hosts.

F. F. Jewell

A morphological study of the vegetative haploid mycelium of *Cronartium fusiforme* in slash pine and *C. quercuum* in jack and virginia pine has been completed. Visual observations and a quantitative measure in microns of the hyphae and haustoria of the rust species in their various hosts were used in attempting to determine any differences between the two fungi. Also, haustorial configuration and location was observed for the rusts in their hosts. A manuscript is being prepared on the results of this research.

Additional research material was obtained including both rust species, each on five species of pine. The galls collected resulted from controlled inoculation with known cultures of each rust species. This material is now being processed for histological examination. If observable differences in the fungi can be detected, this will enable the differentiation of the two rust species on common pine hosts where at present this is not possible with any degree of accuracy. For instance, it will allow researchers involved in breeding pines for rust-resistance to be reasonably certain of which species is involved in progeny test results.

University of MASSACHUSETTS 1

Etiology of maple tree decline in Massachusetts.

W. M. Banfield

In view of the publicity given to salt as the presumptive cause of the decline of roadside maples, a comparative study was made of damage done to small trees by respectively drought, salt, and both. 30 g. of salt (NaCl), about six tons per acre, applied to plants under 12 inches of snow in March had no

effect on their foliage in the next summer, but the same amount in June or September killed all plants. Five g. in June or daily application of a 1 mgm solution from June to September, induced trivial leaf scorch. However, 15 g. at these times caused conspicuous foliar scorch on all plants such that about 1/5 of their leaf area died.

In drought tests run concurrently, all plants developed extensive foliar scorch when the water content of the soil was reduced to between 6 and 8%. Defoliation, dieback, and death followed at lower levels. The water withholding time required to reach the critical level in trees first exposed to salt was about twice that for non-salted trees. The water content of soil around roots of declining field trees on arid sites—remote from any road—was found to range between 1 and 10% at the height of the 1968 drought in this area. The internal pressure for water in the stems of these trees rose to about 80 atmospheres at this time, whereas it remained at about 10 for trees on good sites and in salt treated trees, not exposed to drought. Aside from the similarity of foliar pathology induced by respectively salt and drought, this work does not support the salt thesis. Another possibility is illustrated in fig. 13 where maple decline may be related to pathogen activity.

University of MASSACHUSETTS 6

Virus diseases of hardwoods.

G. N. Agrios

Buds from forest trees showing virus-like symptoms in the last summer of 1967 were transferred to seedlings of several forest tree species in the nursery and in the greenhouse in an attempt to determine the presence of viruses. To date, none of these inoculations has resulted in positive reproduction of the symptoms on the healthy seedlings. Attempts to transmit viruses from the same trees to herbaceous plants by mechanical inoculations have also been unsuccessful. Similar transmission experiments by grafting and by sap inoculations are being continued with the virus-like symptoms observed in 1967, and with additional ones observed in the forest during 1968.

Inoculations of forest tree species (ash, maple, elm, etc.) with buds from virus-infected apple trees showed that, in spite of the wide taxonomic differences, buds from *Malus* and *Prunus* species frequently survive on forest species, and vice versa, for



Figure 13. The *Cytospora* canker is often correlated with the decline of maple trees. Note spore tendrils and mycelium on the Norway maple branch. University of Massachusetts 1.

periods long enough to allow transmission of viruses. Of the apple viruses, apple mosaic was transmitted to European mountain ash (*Sorbus* sp.) on which it produced typical mosaic symptoms. Four other apple viruses (Cortland Latent, Rubbery Wood, Chlorotic Leaf Spot, and Russet Ring viruses) were also transmitted to European mountain ash but they produced no symptoms under the conditions of the experiment. The presence of these viruses in European mountain ash was shown by the fact that when buds of the inoculated but symptomless European mountain ash seedlings were transferred to *Prunus tomentosa* they induced the typical symptoms caused by these viruses on *P. tomentosa*. This very interesting research has been terminated.

PENNSYLVANIA State University 1702

Epidemiology of forest tree diseases. F. A. Wood

The influence of environmental factors on annual and daily patterns of spore release by *Fomes rimosus* has

been studied in the field and laboratory. Two patterns of seasonal spore release were observed. In one, spore release began in mid-April, increased rapidly, remained high through the summer, decreased during the fall, and ceased in November. The second pattern differed in that there were early and late summer peaks of release with a lag during midsummer. Increases and decreases in the rate of spore release during the spring and fall respectively, were positively correlated with temperature. On a daily basis, at sporophore temperatures of 60 F and below, spore release was positively correlated with temperature. At sporophore temperatures of 60 F to 80 F, spore release was diurnal with maximum release at night and minimum release during the early afternoon; sporophore temperature and relative humidity within several inches of the sporophores were not correlated with the diurnal pattern of spore-release. A similar diurnal rhythm of sporulation was induced by fluctuating lights in an otherwise constant environment in a growth chamber. The period of

maximum sporulation was shifted several hours by reversing the light-dark cycle. These results are similar to those obtained with *Fomes annosus* during earlier studies.

TEXAS A & M University 1526

Etiology and control of live oak decline.

E. P. Van Arsdel

Live oak decline is a name that has been applied to a complex of diseases that infect other oaks as well as live oaks. In Texas, the fungus *Cephalosporium* spp. has been identified as a major component of this disease complex. It infects Texas red oak and post oak as well as live oak. *Hypoxylon atropunctatum* accounts for another large portion of the live oak decline in Texas. The fungus disease of Texas red oak (caused by *Dothiorella quercina*) has a *Cephalosporium* stage in culture that looks similar to the *Cephalosporium* found in live oak decline. Thus, the *Dothiorella cuercina* may be a part of the life cycle of the *Cephalosporium* wilt disease. Fungus culture growth investigations of oak diseases appear fruitful in the case of a possible *Cephalosporium Dothiorella* link, and this type of investigation is being expanded to cover a number of the stem diseases found on oaks. So far, investigations have been started on *Hypoxylon Mediterranea* (or *H. nummularia*) and *Polyporus hispidis*. The wilting mechanism in the *Cephalosporium* disease is being investigated. Indications are that the symptoms are being caused by mechanical interference with water flow, the presence of a toxin, or both. Systemic fungicides are being tested as controls, but results are not apparent at the present time.

WASHINGTON State University 1770

Development and pathogenicity of hypoxylon fuscum in NW species of alder.

J. D. Rogers

The original objectives of this project included (1) determining whether or not *Hypoxylon fuscum* kills alder trees and (2) elucidating the life history of the fungus. The results to the present indicate that *H. fuscum* invades trees weakened by other agencies (fig. 14). The degree to which the fungus contributes to killing of trees remains uncertain, however, owing to lack of reliable inoculation techniques and to lack of knowledge of environmental factors involved. Histological, cytological, and growth chamber studies



Figure 14. Hyphae of *Hypoxylon fuscum* in partially degraded vessels of *Alnus tenuifolia*. (macerated wood, safranin stain) Washington State University 1770.

indicated that the fungus is homothallic. It is moreover indicated that the conidia are residual and non-functional spermatizing agents that play no role, or a minor role, in disseminating the organism. Ascospores are the primary inoculum. Current research aims at further clarifying the activities of the fungus on alder in the field.

ADDITIONAL PROJECTS

ALABAMA - Auburn University 911

Ingression of Hypoxylon into Southern oaks.

T. C. Davis

ALABAMA - Auburn University 907

Fungal pathogens associated with littleleaf and seedling diseases of Southern pines.

W. D. Kelley

University of ARIZONA 621

The biology and control of fungi pathogenic to forest vegetation.

R. L. Gilbertson

- University of ARKANSAS 663
Organelles of fungi causing forest-tree diseases.
C. L. Wilson
- University of CALIFORNIA 2348
Microbiology and pathology of wetwood in California firs.
W. W. Wilcox
- University of CALIFORNIA 2383
Studies on the epidemiology and control of Fomes Annosus root rot.
F. W. Cobb
- University of HAWAII 715
The ecology of Phytophthora cinnamomi in forest soils.
E. E. Trujillo and A. H. McCain
- University of IDAHO 11
Decay of inland-northwestern timber trees.
A. D. Partridge
- University of MARYLAND J-101
Forest tree seedlings and soil fungi relationships.
W. L. Klarman
- University of MASSACHUSETTS 7
Lophodermium needle cast disease and ozone damage on white pines.
W. M. Banfield
- University of MICHIGAN 15
Isolation of microorganisms from preservative-treated wood and effect on wood preservatives.
H. L. Morton
- University of MINNESOTA 22-17
Ecology of wood decay.
D. W. French
- University of MINNESOTA 22-18
Dwarf mistletoe.
D. W. French,
M. P. Meyer and F. D. Irving
- University of MISSOURI 540
Fomes Annosus root and butt-rot of Pinus echinata in Missouri.
M. J. Walterscheidt
- NEW YORK - Cornell University 901
Effects of ectotrophic mycorrhizae on tree growth.
E. L. Stone
- NORTH CAROLINA State University 4012
Ecology of forest tree diseases and wood deterioration.
E. B. Cowling and L. F. Grand
- OREGON State University F-819
Phytophthora root rot.
L. F. Roth
- PENNSYLVANIA State University 1488
An annual cranker of maple.
W. W. Ward and F. A. Wood
- University of PUERTO RICO 1
Diseases of forest trees.
J. H. Lopez-Rosa
- University of TENNESSEE 7
Blight resistance in American chestnut.
E. Thor
- University of WASHINGTON 8
Fomes Annosus under stand management in Northwest.
C. H. Driver
- University of WISCONSIN 1264
Oak wilt: Its development, spread and control.
J. E. Kuntz
- University of WISCONSIN 1434
Etiology, epidemiology, and control of forest plantation root diseases.
R. F. Patton
- University of WYOMING 928
Diseases of aspen in Wyoming.
E. A. Andrews

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 nal Vol. 18 (12): 27-31.

Chapter 3

FOREST PRODUCTION

Production Efficiency Research

Program Element 612

The research goals of this program element are directed primarily at production efficiency of non-forest, food and fiber commodities. Research data are necessary to achieve a sufficient supply of quality agricultural food and fibers to meet the expanded demands of export and of an increasing population. Greater efficiency is imperative since the increased demand must be satisfied by supplies obtained from a diminishing land area.

RANGE MANAGEMENT

Research Problem Area 112.

Forestry research extends into this problem area because range and forest plant communities overlap and because multiple use concepts frequently relate livestock grazing and forested lands. This is important in the western states and all research activity is in that part of the country.

Northern ARIZONA University 5

Range Forage on Parks in Ponderosa pine.

L. D. Love

Installation of instruments to measure local climate and edaphic factors at three stations was completed. Preliminary analysis indicated a difference in the air temperature regime between the park and forest stations due to the dense stand of trees. The border station is exactly duplicated at the forest and park stations. Solar radiation on clear days at the border station averaged 76% of that received at the park station; for the forest station, the average was 70%. Wind movement at the border and forest stations was markedly below that at the park station. Weekly minimum air temperatures at the three stations did

not rise above 32 degrees F until late in June and dropped below freezing in early September. Soil moisture remained below 15 atmospheres at the 12- and 24-inch depths at all three stations from mid October, 1967, until the fall of 1968; above the 12-inch depth, soil moisture exceeded 15 atmospheres beginning in June. During the period of record no soil freezing occurred. This is attributed to a heavy snow cover that occurred in December 1967. In general, soil temperatures were lower at the forest station than at the other two. The instruments, as installed, have provided a good measure of the general climate in the vicinity of a natural grassland park (fig. 15) as well as the extent of minor variations between the park, border and forest stations.

ADDITIONAL PROJECTS

University of CALIFORNIA - Berkeley 2500

Ecological adjustment of range plant populations to management practices and environment.

H. F. Heady

University of IDAHO 12

Effect of livestock trampling on plant growth and forage productivity.

L. A. Sharp



Figure 15. Park station with instruments placed approximately 1 foot and 16 feet above the ground surface. Open-grown (border) trees surround the grassland park. Northern Arizona University 5.

NEW MEXICO State University 1

Vegetation changes on protected range.

R. D. Pieper and D. D. Dwyer

University of WYOMING 879

A study of the forest margins.

M. May and L. I. Painter

PUBLICATIONS

Pieper, R. D.

1968 *Comparison of vegetation on grazed and ungrazed pinyon-juniper grassland sites in Southcentral New Mexico.* J. Range Manage. 21: 51-53.

Timber Production Research

Program Element 693

The great variation in the timber resources of the United States requires continuing knowledge of their condition and availability obtained with improved techniques of measurement including aerial photography and remote sensing. Computer simulation is receiving research attention for use in land management to make timber production goals compatible with other public and private land uses.

APPRAISAL OF FOREST AND RANGE RESOURCES

Research Problem Area 110.

The forest resources of the United States are found in over 500 million acres of commercial forest land and are widely divergent in growth, depletion, and quality of timber. The necessity for continuous resource survey is impelled by the constant and sometimes very rapid changes that occur on a local and national level. Twenty-one projects at 16 institutions attest to the importance of this kind of research.

CONNECTICUT - New Haven 414

Multivariate analysis of permanent plot data in hardwood forest. D. B. Woods and P. E. Waggoner

The permanent plots were re-sampled in 1967, and 1968 was devoted to the preparation of these extensive data for machine analysis. That is, all of the 1967 data and corrections in the 1927, 1937 and 1957 data were punched into cards.

MICHIGAN State University 982

The ecology of shrubs of wildlife food and aesthetic value. L. W. Gysel

Staghorn sumac is becoming less abundant in the Manistee National Forest in Michigan due to the lack of disturbance and competition with economically important species. This plant (See fig. 16) is a major wildlife food species, and therefore we have attempted to quantitatively analyse its ecology, wildlife use, and nutritional value.

The ecological aspects of this study are primarily related to sumac productivity, site evaluation, and reproduction. Currently in its second year of being

monitored for wildlife use, staghorn sumac has proved to be a very important winter deer browse. In the final phase of this study, the nutritional value of the stems and fruits will be determined.

Research results will indicate possible management procedures for breaking seed dormancy, establishment of seedlings, and methods for the rejuvenation of quiescent root systems.

MICHIGAN Technological University 2-3015

Distributional patterns of Eastern hemlock reproduction. P. S. Johnson

Project objectives and degree of accomplishment were: (a) To detect stand expansion patterns: This was difficult to conclusively determine because of prevalent heartrot and other internal defects in hemlock; however, certain generalizations could be made from data collected (b) To determine response of hemlock seedlings to variations in soil moisture and types of seed-bed materials: This aspect of the study is continuing, currently as unsponsored research.

An abbreviated summary of observations made in this eastern hemlock study reveal: 1. Evenaged "pockets" of hemlock within larger hemlock stands could not be detected using the age estimates available. Consequently, periodic or cyclic phenomena, such as seed production and climatic factors, could not be related to stand establishment or expansion. 2. A curve of double bark thickness at d.b.h. was constructed to facilitate estimates of hemlock ages for trees with heartrot. 3. Measurement of pH of 224 soil and surface organic (forest floor) materials did not indicate any apparent relationship between pH and hemlock establishment. 4. Hemlock regeneration is most prevalent under young, moderately well-stocked stands of oak, white birch, yellow birch, and aspen.



Figure 16. Both the fruit and stems of staghorn sumac are important deer browse. The plant shown above has produced 28 fruits. Michigan State University 982.

5. An abundant seed crop occurred in 1967 but the seed collected failed to germinate even when subjected to various stratification periods, photoperiods, temperatures, and germination media.

NORTH CAROLINA State University 4015

Geographic variability in yellow-poplar.

R. C. Kellison

To obtain information basic to tree breeding programs, a study to determine the geographic variability of yellow poplar in North Carolina was initiated in 1962. A total of 108 trees, occurring from near sea level to 4000 feet elevation, were studied to determine differences in morphology, wood properties, and the environment under which the trees were growing. With the exception of one area where a distinct ecotype is thought to occur, a general clinal

pattern of variation was found for most characteristics, increasing in magnitude from low to high elevations. Seed were collected by mother tree in 1962 and the resulting progenies were planted at each of three locations in 1964. The locations represent the Coastal Plain, Piedmont and mountain provinces of North Carolina. Each location planting was established by a completely randomized design, consisting of 10-tree row plots, replicated four times. The total area for the three plantings is 18 acres. Survival and total height values were obtained after the second (1965) and fourth (1967) growing seasons. Preliminary indications are that the Coastal Plain sources, when planted inland, grow more rapidly than local sources but are extremely susceptible to cold (fig. 17). Annually they freeze to ground level after which they sprout and grow rapidly during the growing season. As a result, many of the progenies have developed a bush-like appearance.

AVERAGE HEIGHT IN CENTIMETERS

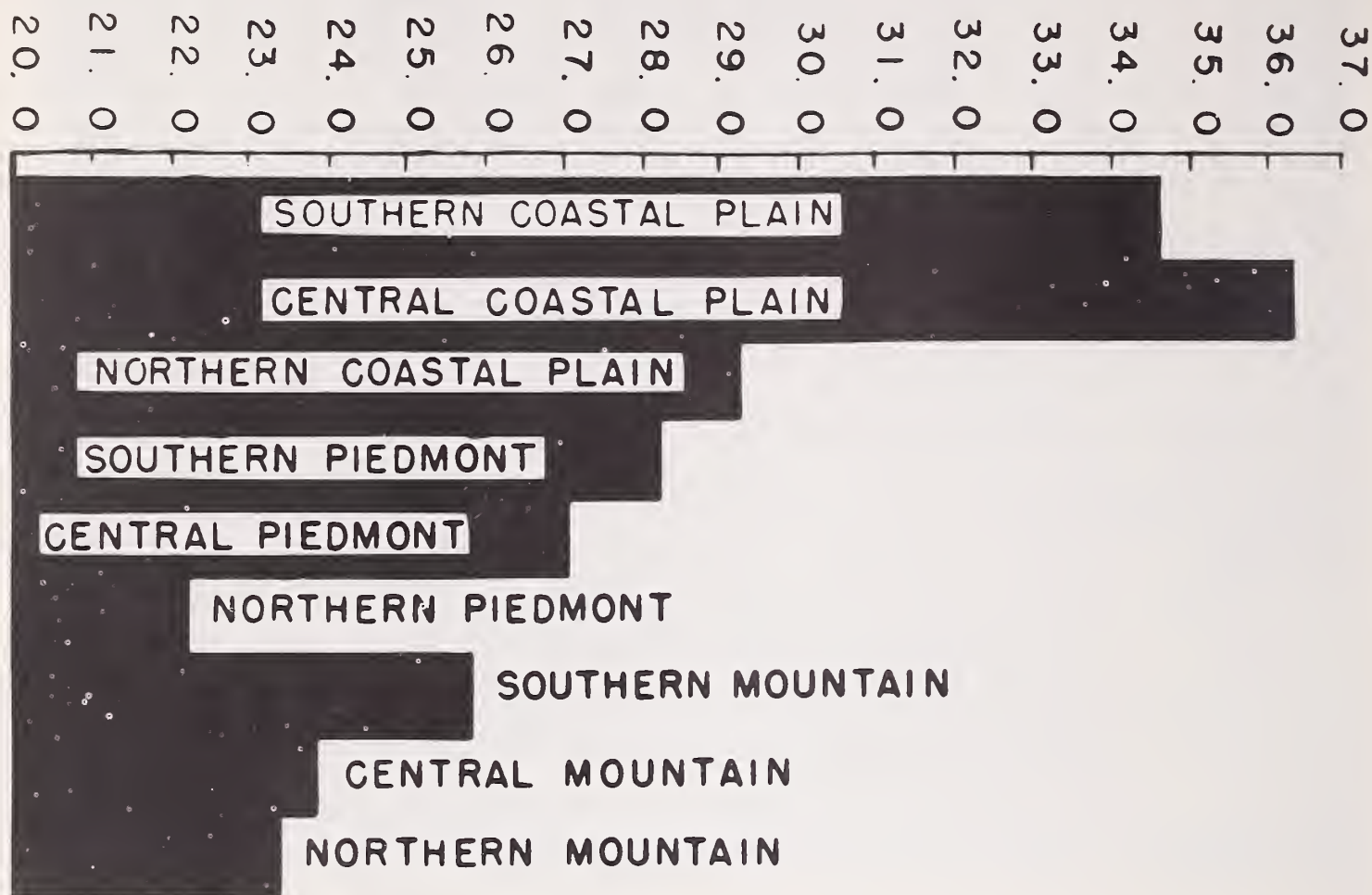


Figure 17. Variation in height growth of yellow-poplar seedlings by seed source is striking when grown near Raleigh, N.C. on the Piedmont - Coastal Plain transition zone. The more rapid growing Coastal Plain sources are highly susceptible to cold when planted in continental provinces. North Carolina State University 4015.

OKLAHOMA State University 1236

Development of aerial volume tables for central Oklahoma mixed hardwoods. D. W. Robinson

Because existing standard volume tables do not adequately predict volumes of trees found in the central Oklahoma stream bottoms, a decision was made to develop a local volume table which could be applied to these stands. This volume table was developed and the results were presented in an experiment station publication.

ADDITIONAL PROJECTS

ALABAMA - Auburn University 909

Standardized forest condition classes for aerial forest inventory. E. W. Johnson

Northern ARIZONA University 1

Ponderosa pine stand density measures. C. O. Minor

University of CALIFORNIA - Berkeley 2520

Mathematical simulation of forest stands. L. C. Wensel

University of IDAHO 1

Site relationships and productivity of foothill woodland-shrub grazing lands in Idaho. E. W. Tisdale

Southern ILLINOIS University 4-67

Dendrochronology of shortleaf pine. W. C. Ashby

INDIANA - Purdue University 1269

Measurement and management planning of small woodlands. T. W. Beers

INDIANA - Purdue University 1477

Ordination for forest ecosystems. C. Merritt

MICHIGAN Technological University 2-3012

Development of a standardized program for automatic data processing of forest measurement records. J. W. Meteer

University of MISSOURI 625

Multivariate analysis of forest ecological data. D. Duncan

NEW YORK - State Univ. College of Forestry at Syracuse University 10-272A

Growth Studies of Forest Tree Species. H. B. Tepper, H. E. Wilcox and F. A. Valentine

NEW YORK - State Univ. College of Forestry at Syracuse University 1

Forest Sampling. C. A. Bickford

NORTH CAROLINA State University 4013

Taxonomy, distribution, and ecology of Carolina Shagbark hickory. A. W. Cooper and J. W. Hardin

NORTH CAROLINA State University 4014

Estimation of parameters in non-linear models of tree growth. W. L. Hafley

OREGON State University F-822

Tree volume by height accumulation. D. P. Paine

OREGON State University F-823

Effect of spatial distribution on sample variance. D. P. Paine

OREGON State University F-841

Three-P sampling and optical dendrometer for cubic-foot growth on forest areas. J. F. Bell

UTAH State University 757

Conifer distribution in the Great Basin and adjacent mountains. R. M. Lanner

University of VERMONT 4

Volume equations for major forest trees. L. E. Zei

PUBLICATIONS

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Payandeh, B.

A computer simulation study of the relative

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Roberds, J. H. and R. C. Kellison.

Technical Report No. 37. N.C. State University, Raleigh. 44 pp.

1968

Zobel, B. and M. Matthias.

Moisture content of Southern pine trees.

1968 Tech. Report 37. North Carolina State University. 44 pp.

TIMBER MANAGEMENT

Research Problem Area 111.

The timber resources of the nation grow under a wide variety of climatic conditions and have been harvested, often many times, with the result that tree and plant communities are modified; continuing management decisions must also be modified on a firm basis of research data. Computer techniques are the subject of a number of the 65 projects in this area.

University of ALASKA 0541

Forest succession and soil moisture retention on upland sites in the Fairbanks area. B. J. Neiland

Summer 1968: Soil moisture measurements were continued in the recent burn, and the 50 and 125 year old stands studied in 1967, both to improve the methods and to compare some of the moisture patterns during the dry summer of 1968 with those of the wet summer of 1967. Both manometric and gravimetric measurements were made during a three week period in late summer. A tentative finding that the exposed burn soil seemed to have retained more moisture at the 3"-8" levels than had the soils of the forested sites warrants much more intensive and specific investigation. Fifteen recent burns of the

same array of exposures, elevations, and slopes as the mature stand previously analyzed were located. Preliminary reconnaissances were made and species lists compiled. Relatively undisturbed soil cores were taken, and these, with the remainder of the mature forest cores, will have tension curves run on them. *Summer 1969 projected:* Complete vegetational analyses of the fifteen burns will be made. Five of the burns match well in site characteristics and are fairly near five of the mature stands. Seasonal moisture patterns will be followed in these paired stands.

CALIFORNIA - Humboldt State College 4

Productivity of hardwood species in Humboldt County. H. V. Wiant

An individual local tree volume table has been completed for tanoak (*Lithocarpus densiflorus* (Hook. and Arn.) Rehd.) and presented to local timber companies supporting this study. The standard deviation for tariff numbers of trees selected by point sampling for table construction ranged from 3.13 to 5.17. Examination of tanoak stands in Humboldt County indicates that standard deviation will rarely exceed five. An estimate of the number of sample trees necessary for certain confidence levels in the average tariff number can be found for stands of tanoak in Humboldt County by using this value in the appropriate formula.

After obtaining field data for construction of a local volume table for Pacific madrone (*Arbutus menziesii* (Pursh.)), difficulties were encountered in choosing a variable that would account for differences in volume and tariff number due to forking of stems in this species. This project has been terminated.

CALIFORNIA - Humboldt State College 6

Soil moisture drying curves - Management Relations. M. B. Rhea

Three-dimensional soil moisture drying graphs were constructed, utilizing data collected from June 1966 to September 1967 on eight different plots, each with five neutron soil moisture meter access tubes. The south slope plots, within each grassland type, had significantly less stored moisture than did their north slope counterparts. This was the result of higher air temperatures and more direct isolation on these southerly exposures. The period of soil moisture

recharge was the same for all plots, but the period of depletion lasted longer on the ungrazed plots than on the grazed. Virgin timber plots had less seasonal variation of soil moisture than the cutover plots, especially in the surface horizons. Such a relationship may be attributed to fog drip in the virgin stands adding moisture to the upper horizons during the summer months and offsetting the moisture utilization by the vegetation. Little difference was found between aspects on the virgin redwood plots, but for the cutover plots, the south slope showed a significantly greater depletion. The average bulk density on the timberland plots generally showed a curvilinear increase with depth. Bulk densities as low as 0.85 were found on the virgin redwood plots. This research is now terminated.

COLORADO State University 317

Soil-site relationships in lodgepole pine stands in Northern Colorado and Southern Wyoming.

E. W. Mogren

This research was designed to determine if differences do exist in lodgepole pine growth on major soil groups in northern Colorado and southern Wyoming. If differences do exist, to determine which soil characteristics are related to growth, and to establish soil characteristics-site index relationships for lodgepole pine. Study locations were selected to include as wide a spectrum of lodgepole pine sites as could be found in the study area. Eighty plot locations are to be included in the study; sixty have been measured and evaluated to date. A soil pit was used to establish the edaphic characteristics of the location; physiography was also noted. Eight dominant trees were measured to establish site index values at each location.

Simple correlations have been tried between site index and an array of independent variables. Those that show the greatest promise are: (1) depth of solum, (2) soil texture, (3) percent rock in solum, (4) available soil moisture, (5) percent slope, (6) aspect, and (7) elevation. Subsequent analysis of data will be done by partial regression using the reciprocal matrix procedure of Doolittle-Fisher-Dwyer.

Southern ILLINOIS University 67-5-014

Native trees for parks.

D. R. McCurdy

The increasing demands being placed on our parks and recreation areas is creating a need for manage-

ment of the developed site. On many areas use has become so heavy that it exceeds the site's natural capacity to repair itself. For example, soil is compacted, roots are exposed, and trees are damaged on campgrounds and picnic areas. The result is a recreation area or park devoid of much of its natural charm. Therefore, as use becomes heavy, park and recreation area planners and managers must supplement a site's natural capacity to repair itself through applied management techniques. Treatments will need to be tailored not only to the use planned, but to the species and their individual characteristics. For example, a situation might warrant thinning a stand of young trees to increase ground vegetation and make it more durable. The degree to which the stand can be thinned will depend on the species present and their resistance to such factors as windthrow, sunscald, and epicormic branching. In another case, there may be a need for using trees as a screen. Here, the park planner might best select a species that grows relatively fast and contains dense foliage.

This study entailed a synthesis of characteristics of 50 native trees that affect their suitability for the various uses that they may be put or the silvicultural treatments that may be required in parks and recreation areas in Illinois, Indiana, and Ohio. Only native trees were chosen because National Park and State Park policy dictates that only native trees be used within their boundaries. The work has been completed and a book with the information is being written. A guide that can be used in determining a tree's suitability for various park uses is also being developed.

INDIANA - Purdue University 1586

Data processing for small woodland management.

J. W. Moser, Jr. and C. C. Myers

To expedite timber sale and management planning inventories on small woodlands in Indiana, a computer program was written to summarize data collected by complete enumeration, fixed radius plots, or various point sampling methods. This program was developed as a modular package of subroutines and function subprograms. Such a procedure facilitated program modification and eliminated duplication of computational steps that are common to most inventory summarizations. Through the organization of a Data Processing Service, the program was made available to Indiana CPM and Extension Foresters.



Figure 18. Indiana CFM forester and woodland owner discussing the computer summarization of trees marked for a timber sale. Purdue University 1586.

During the past year, approximately 200 jobs were submitted and processed to provide timber management assistance to landowners. One such contact is shown in fig. 18. Currently, program refinements are being incorporated and provisions are being made to have the Data Processing Service available through a remote batch entry system.

MICHIGAN State University 978

Financial evaluation of forest management opportunities.

V. J. Rudolph

Analysis of data for 25 privately-owned second growth northern hardwood forest areas in northern Lower Michigan which received timber stand im-

provement treatment in 1962 under the federal ACP cost-sharing program indicates such practices are economically feasible in most cases. The decision-tree approach was used to evaluate the formulated model describing 30 options available to each ownership, with the internal rate of return as the measure of effectiveness. IRR values ranges from 2 to 20%, with the highest returns being associated with TSI via ACP payments, followed by periodic thinnings, ending with marketing cut products from the areas.

Costs and returns analyses for growing four Christmas tree species for which production periods, costs, and selling prices span a wide range, show that the most profitable species to grow is Scotch pine, followed by white spruce, Douglas fir and blue spruce, in that order.



Figure 19. A typical, privately owned second-growth northern hardwood stand in northern Lower Michigan. Timber stand improvement under the ACP program, followed by periodic thinnings until maturity, can increase up to tenfold the projected internal rate of return. Michigan State University 978.

University of MINNESOTA 19-38

Application of computer technology and o.r. techniques to forest inventory and management.

H. H. John

Forest inventory design efficiency generally requires two or more plot types and/or sizes to meet requirements posed by multiple objective forest inventories. Valid statistical procedures are required if the two or more plot types are to be combined in estimation of the selected parameters. Such combining must be done by a weighting scheme, preferably a scheme which minimizes the combined variance. This can be accomplished if the variance function for a given plot type is known.

Three pine stands were selected and all trees mapped. A computer program was written which would develop repeated samples from these data, 11 sizes of fixed radius plots, and 11 sizes (BAF) of variable radius plots. Fig. 20 shows the relationship between variance and plot size of two plot types. These variance functions are fitted using Smith's model: $V=ka^{-b}$ where V is the variance, k and b are constants, and a is plot area. The value of b for the

Cutfoot and Cloquet stands was approximately 1, while the value of b for Portage Lake was approximately 0.5. The spatial distribution of the first two were fairly uniform while the latter had a patch distribution. This is in general agreement with data of other researchers.

For the Cloquet and Cutfoot stands, the weighting factors can be generalized with the following equation:

$$w_i = n_i a_i / \sum n_i a_i \quad (i=1,2,\dots,m)$$

In the case of now-uniform distribution where the value of b is 0.5, the generalized weighting factors are given by:

$$w_i = n_i \sqrt{a_i} / \sum n_i \sqrt{a_i} \quad (i=1,2,\dots,m)$$

Where w is the weight for a particular plot type, n is number of samples, a is plot area, and m is the number of different plot types.

The effectiveness of using these approximate weights versus the weights based on population variances was tested. The agreement between the approximate and

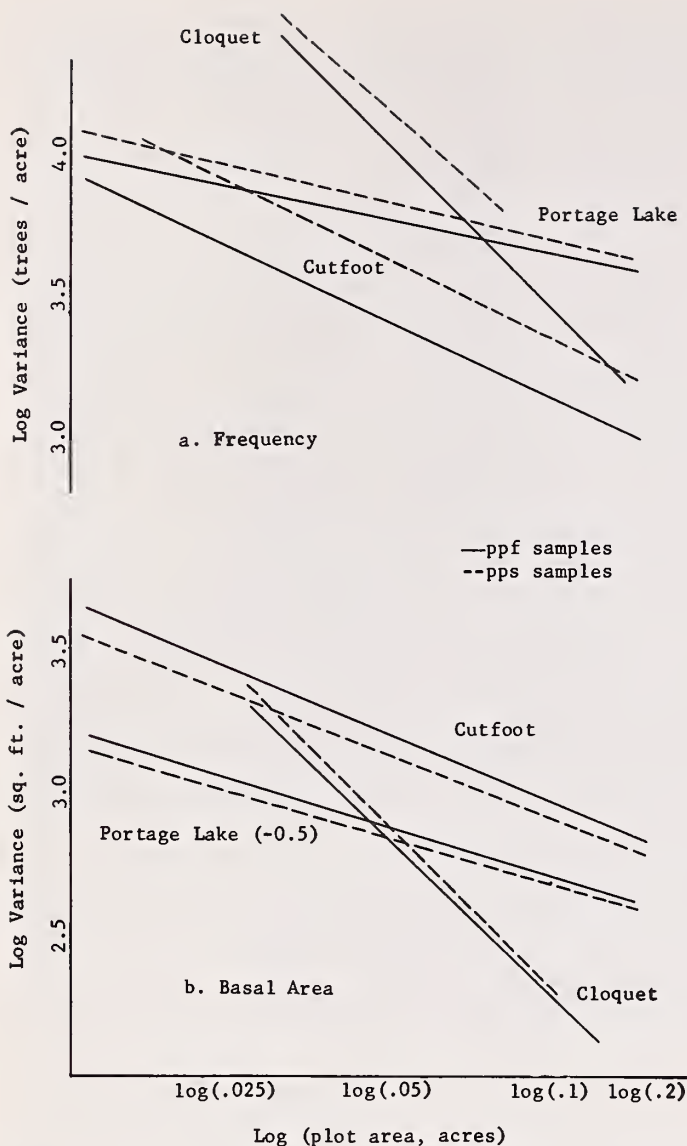


Figure 20. Variance functions for all size classes combined. University of Minnesota 19-38.

actual weights were good except for extreme differences in plot sizes and areas.

University of MINNESOTA 19-79

The ecological foundations of forest production in Minnesota. E. V. Bakuzis

Development of methods of systems analysis applicable to forest ecology and to solution of problems of forest production were continued. Over 1000 soil and 3000 plant analyses were completed in quantification of ecosystem coordinates (moisture, nutrient, heat and light regimes) and evaluation of species' properties. Sites were selected and other preparatory work done for energy balance studies. Spatial-temporal pattern analysis was continued by comparing measurements on concentric plots of living, dead, and cut trees in 60 sample areas; in addition, all trees were mapped in a stand of about 5 acres.

Ecosystem coordinate systems, spatial-temporal patterns, and species' control mechanisms provide the theoretical framework for forest ecological investigations. Productivity information is being accumulated and interpreted within this framework (fig. 21) to obtain the guidelines for forest management. The results indicate that in the Central Pine Section of Minnesota, productivity can be raised in specific conditions by substituting red pine for jack pine, by expanding conifer cultivation, and by fertilization and drainage. The methods already developed allow identification of the limiting conditions and prediction of expected responses to a considerable degree.

MISSISSIPPI State University 1120

Stem form and stand density of loblolly pine.

R. D. Ross

A regression equation for "maximum crown area" ($MCA = 0.0044D^2 + 0.0268D + 0.0411$) yields the expected occupancy of the crown of a free-growing loblolly pine for a given d.b.h. The summation of all MCA values on an area leads to a relatively new measure of stand density called "crown competition factor." Crown competition factor was shown to have value as a measure of stand density through its independence of age and site.

Regression equations were developed for predicting Girard form-class and taper-line slope. The latter is a linear sectional area-height curve which is related to volume in cubic feet. Three variables involving crown measurements explained much of the variability associated with both these measures of taper. The project was terminated during the fiscal year.

University of NEVADA 674

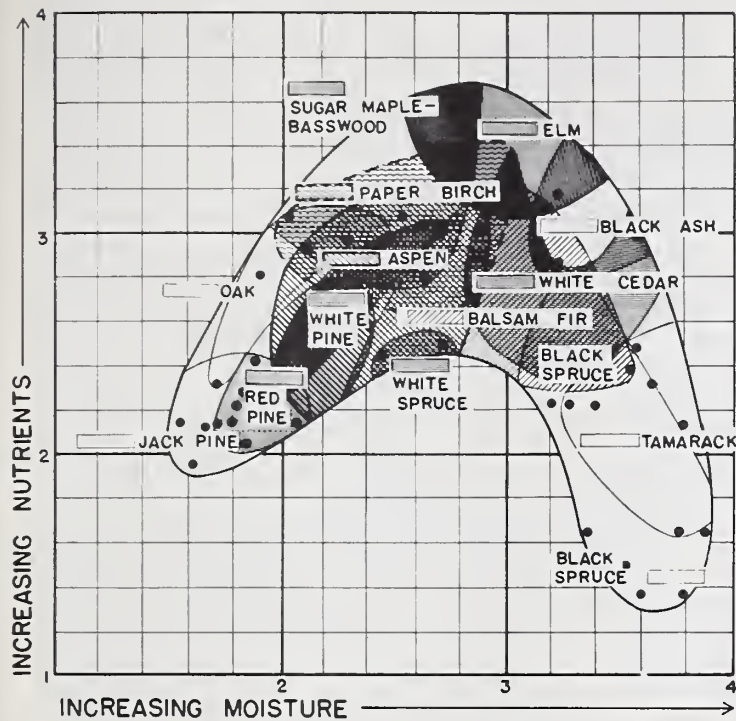
Species adapted to erosion control planting.

C. M. Skau

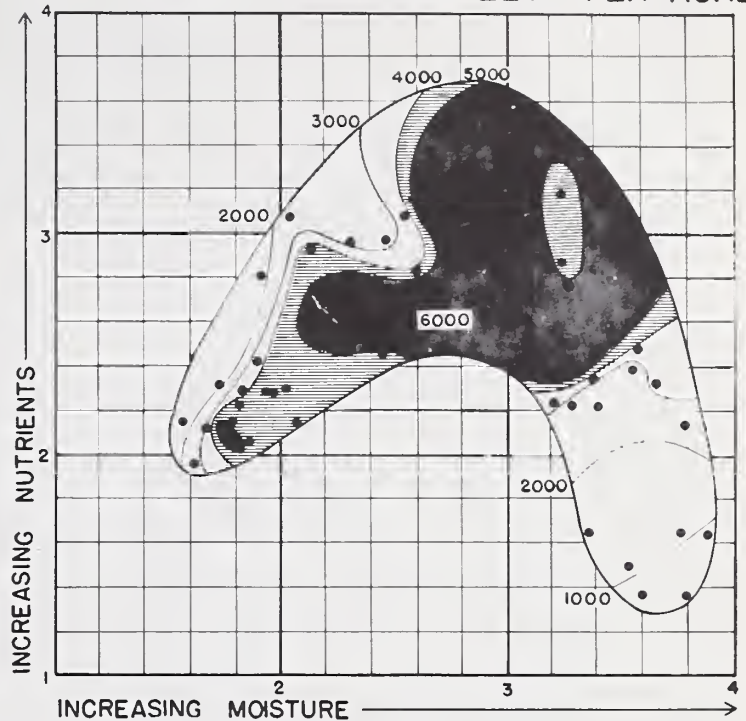
40-70% slopes, sandy infertile and water repellent soils derived from decomposed granites, a short growing season, drougny summers, and a history of wildfires, overgrazing and uncontrolled logging combine to create critically erosive watersheds on the Eastside Sierra Nevada. In Nevada, this affects 40% of the Lake Tahoe Basin, and creates flood and sediment problems for downstream urban and agricultural areas. Reestablishment of vegetation for erosion and flood control as well as aesthetics and game food is the objective of this study. The general approach to

• SAMPLE AREAS

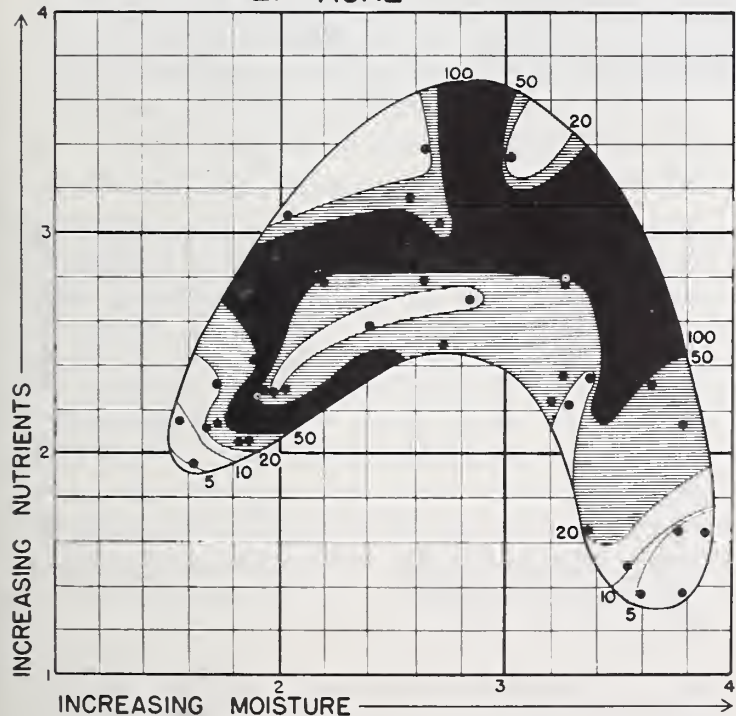
1. DISTRIBUTION OF MAIN TREE SPECIES



2. TOTAL VOLUME OF LIVING, DEAD, AND CUT TREES IN CUBIC FEET PER ACRE



3. NUMBER OF STEMS OF SHRUBS AND ADVANCE REPRODUCTION IN 1000 PER ACRE



4. VOLUME OF SHRUBS AND ADVANCE REPRODUCTION IN CUBIC FEET PER ACRE

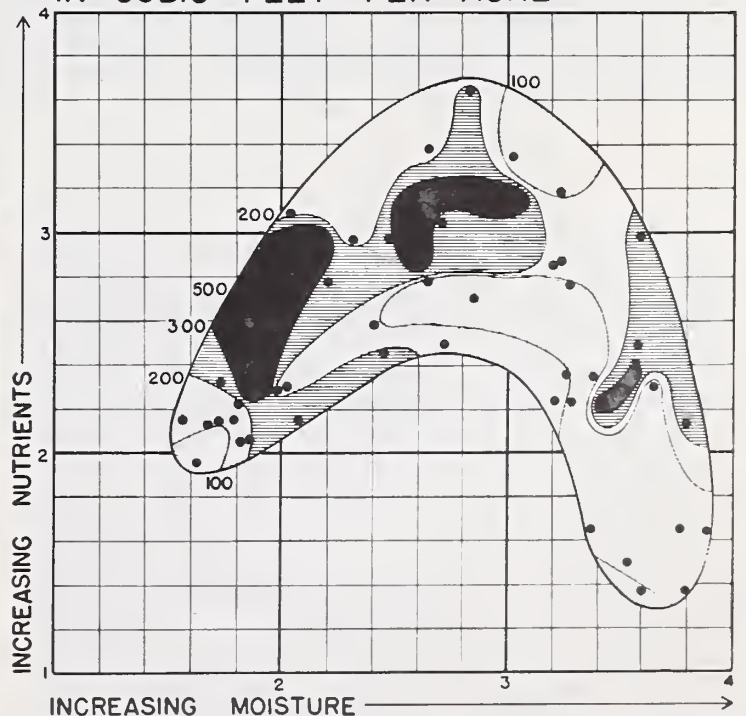


Figure 21. Characteristics of distribution of 55 sample areas of mature and nearly mature forest stands of Central Minnesota Pine Section in relative moisture-nutrient coordinates. 1. Distribution of tree species contributing 20% and more each to the total stand basal area. 2. Total cubic-foot volume per acre of all living, dead, and cut trees showing the response to moisture and nutrient conditions and the effect of competition of trees, shrubs, and other species. 3. Number of stems of shrubs and tree reproduction. 4. Distribution of shrub and reproduction volume shows three maxima. University of Minnesota 19-79.



Figure 22. Typical steep slope at 8,500 feet. Bare area is 10 year-old logging road with usual absence of any revegetation. Notice white flags identifying spots where seedlings were planted. This area was planted with 2-0 Jeffrey pine three years ago. Survival is 17%- among the best. University of Nevada 674.

date includes screening of numerous tree and grass species in field tests under a variety of natural and artificial microenvironments. Survival or establishment during 3 years is best described as disastrous; e.g., of over 10,000 seedlings and 400 replications or treatments, maximum survival was 27% (Jeffrey pine, bare soils, S E slope) with 0-5% most common. One of the better areas for Jeffrey pine survival is shown in fig. 22. An experimental nursery has been established by cooperation with the Nevada Division of Forestry to minimize handling losses and to grow seedlings from domestic and foreign seed sources.

University of RHODE ISLAND 954

Evapotranspiration losses as related to site and vegetation differences.
J. H. Brown

The major objective of this project is to obtain information on evapotranspiration losses from typical Rhode Island forest stands and, so far as possible, relate these losses to vegetation types taking into consideration topographic and soil differences. Losses were computed for 1966 and 1967 and were found to range from about 18 inches to 26 inches for an entire growing season. Although data indicated relationships

between losses and aspect as well as species, sampling was not sufficient to warrant definite conclusions. More thorough sampling of forest stands has since been accomplished. During the 1968 growing season soil moisture content was monitored (fig. 23) weekly from 63 neutron-probe access tubes located in 8 forest stands. Since mixed-oak is the predominate forest type in southern New England, sampling has been concentrated in this type. Mixed-oak stands representing a north slope, a south slope as well as a level location have been sampled; each contain a total of 9 access tubes. From these data estimates of evapotranspiration losses based upon changes in soil moisture content from field capacity will be obtained. Plans call for the evaluation of these losses to detect differences and similarities between soils, aspect and forest type.

SOUTH CAROLINA - Clemson University 706

Timing of harvest in even-aged timber stands.

J. R. Warner

CUFM (Clemson University Financial Maturity) is a computer program being developed from several fragmented programs in working toward a semi-automated forest record system. The forest stand is

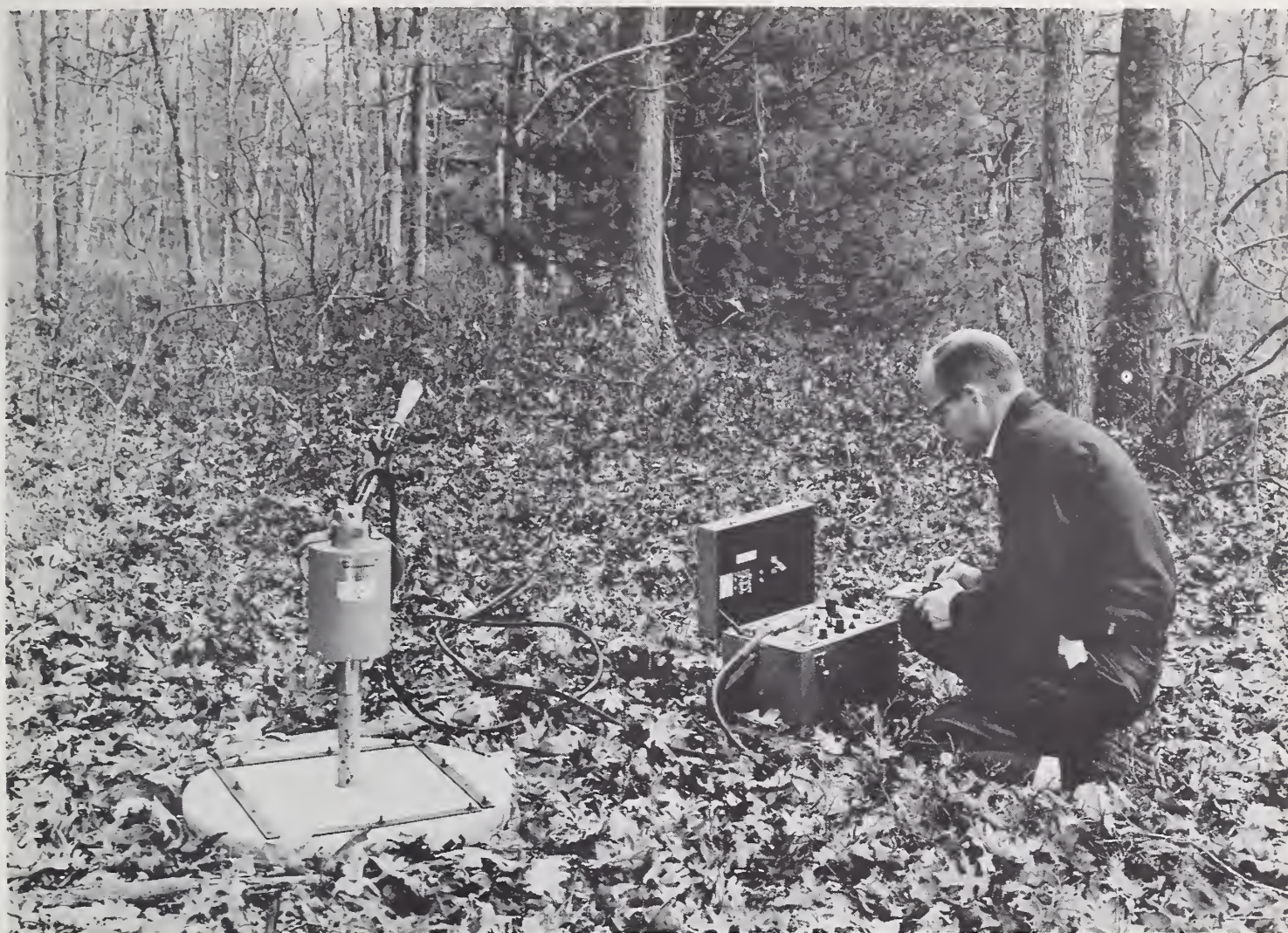


Figure 23. Monitoring station for soil moisture content. University of Rhode Island 954.

the basic record unit while the forest division is the basic computer file. Eventually 15 such files will form the record system for the Clemson Forest. Work during the past year has centered on building the complete record for each stand of the Issaqueena Division file for the Clemson Forest.

An important part of CUFM, over and above record monitoring and updating, is the summary of stand record information into a projection of anticipated stand development over the period of the next 5 years. The objective of such a projection is to evaluate the stand as an investment based on constraints entered by the owner or forest manager. Such stand projection summaries can then be used in management decisions when compartments containing these stands are under consideration for current operations as management operations proceed through the forest. One more question is posed by the foresters as in fig. 24.



Figure 24. This pine stand is biologically mature. Where does it rank on the financial maturity scale? Clemson University 706.

Selection and propagation of woody plants for the Northern plains. D. E. Herman

Sugar maple seedlings germinated from 1967 seed collections will be lined-out next spring. Additional seed collections are planned. There was no seed crop in 1968. Several hundred sugar maple cuttings were rooted in June, 1968, from two native trees growing in northeastern South Dakota. Both trees take on an attractive red fall color. Excellent success was obtained in rooting softwood cuttings with an IBA application. Cutting propagation will include a number of new sources next spring.

A collection trip was made this fall to make *Juniperus* selections. An extremely attractive form of *J. horizontalis* was collected in the Black Hills of western South Dakota. Cuttings were taken from 18 different naturally columnar Junipers, *J. scopulorum*, in the North Dakota Badlands. A *J. communis* var. *depressa* selection was also made. This work will also be expanded.

Work is underway to obtain European seed sources for selection within *Pinus mugo*.

A lilac propagation study was carried out to determine proper timing and auxin concentration. A triplicated rooting study with four varieties gave excellent results when cuttings were taken May 11. A follow-up experiment two months later, July 11, resulted in a marked decline in rooting potential. Plans are to repeat this experiment in 1969 followed by publication of results.

Over 200 taxa of woody plants were obtained from U.S. and also Canadian sources in 1968. A majority of these plants are newly named cultivars or plants which have not previously been adequately evaluated for potential use in South Dakota.

VIRGINIA Polytechnic Institute 350051

Growth of mixed hardwoods. J. P. Barrett

The multiplicity of species in the mixed hardwood forest leads to many difficulties in the study of growth and yield. Data from 167 permanent sample plots on the Jefferson National Forest are being examined by a variety of classification and ordination

methods to determine which taxa can be combined for further study. The current practice of data collection involving the combination of species groups, for instance the hickories, on loss of information from sample plot data is also being examined.

University of WYOMING 880

Biotic communities of forests and grazing lands. H. G. Fisser

Six new limber pine study sites were located in the Bighorn Mountains, Wyoming. Paired with each of these were adjacent comparable sites of spruce-fir or lodgepole pine. On each of the sites, vegetation was measured in terms of overstory density by tree species, size, age, understory cover, composition, and frequency. Soil and duff data were obtained as well as information concerning small mammal, bird, and ungulate use of the study areas. Limber pine apparently acts as a pioneer species prior to establishment of other conifers which replace it. Preliminary studies indicate that it commonly establishes on arid sites with little soil development. Concomitant with development of more mesic environmental conditions, the limber pine is gradually replaced by tree species such as those listed above and associated forest shrubs and herbs. More precise information will be available when the present data are fully analysed and publications completed.

ADDITIONAL PROJECTS

ALABAMA - Auburn University 904

Physiological factors affecting resistance of woody plants to certain phytocides. M. C. Carter

ALABAMA - Auburn University 908

Development of improved practices for nursery production of selected Southern hardwoods. H. S. Larsen

University of ALASKA 0504

Nutrient cycles in selected interior of Alaska forest types. K. Van Cleave

University of CALIFORNIA - Berkeley 2179

Ecological potential of Coast redwood. E. C. Stone

- CALIFORNIA - Humboldt State College 10
Removal of competing pampas grass from redwood reforestation areas. D. Thornburgh
- CALIFORNIA - Humboldt State College 12
The regeneration of redwood following selective cutting. D. Thornburgh
- COLORADO State University 315
Ponderosa pine-bitterbrush. H. W. Steinhoff and G. M. Van Dyne
- CONNECTICUT - New Haven 405
Environment and photosynthesis. D. N. Moss
- University of FLORIDA 1130
Correlation of soil survey information with tree growth. W. L. Pritchett
- University of FLORIDA 1344
Improvement of sand pine for reforestation of the Florida sandhills. R. K. Strickland and R. E. Goddard
- University of GEORGIA 16
Relationships between site and growth of swamp and water tupelo. J. T. May
- University of IDAHO 10
Influence of elk and cattle on reforestation. F. H. Pitkin
- Southern ILLINOIS University 64-R-4
Hardwood planting on upland old-field in Southern Illinois. C. A. Budelsky
- KANSAS State University 672
Christmas tree production. R. W. Funsch
- LOUISIANA Polytechnic Institute 1
Forestry yield data from responses to thinnings of natural even-aged stands of loblolly pine. E. R. Andraulot, L. P. Blackwell and J. E. Carothers
- LOUISIANA Polytechnic Institute 2
Effects of annual burning on longleaf pine. P. B. Moseley and L. P. Blackwell
- LOUISIANA Polytechnic Institute 4
Nuclear methods for determining forest soil site index. C. G. Hobgood and J. Kuprionis
- LOUISIANA State University 1237
Producing and marketing Christmas trees. B. H. Box
- LOUISIANA State University 1266
Competition in slash and loblolly plantations. T. D. Keister
- LOUISIANA State University 1276
Rooting depth of mature Southern pine trees as limited by soil characteristics. N. E. Linnartz
- MICHIGAN State University 984
Optimizing site conditions for the establishment and growth of high quality black walnut. D. P. White
- University of MINNESOTA 17-85
The effect of small mammals on forest reseeding. J. R. Beer
- University of MINNESOTA 19-16
Environmental factors related to the failure of red pine reproduction. B. A. Brown
- University of MINNESOTA 19-18
Evaluation of tubelings for forest regeneration. A. A. Alm
- University of MISSOURI 543
Financial aspects of silvicultural practices. R. C. Smith
- University of MONTANA 210-302
Prescribed burning after timber harvesting in the Northern Rocky Mountains. R. W. Stelle

University of MONTANA 1001

Soil moisture as a determinant of plants and animals in forest communities.
T. J. Nimlos

University of NEVADA 670

Evapotranspiration patterns of forest and brush vegetation on east slope of Sierra Nevada.

C. M. Skau and J. S. Swant

University of NEVADA 671

Establishing Jeffrey pine on brushy slopes.

C. M. Skau and G. A. Ahlstrom

NEW MEXICO State University 5

Soil-site requirements for ponderosa pine.

A. G. Wollum

NEW YORK State University College of Forestry at Syracuse University J

Deer habitat studies.

D. F. Behrend

OKLAHOMA State University 1237

Mortality in commercial timber.

T. H. Silker

OKLAHOMA State University 1247

Tree distribution by major forest types of the United States.

N. Walker

OKLAHOMA State University 1360

Control of undesirable woody plants.

T. H. Silker

OREGON State University F-600

Douglas-fir survival under drought stress.

D. P. Lavender

OREGON State University F-646

An ecological framework for forest land management in Southwestern Oregon.

R. H. Waring

OREGON State University F-761

Mechanisms of succession.

M. Newton and W. W. Chilcote

OREGON State University F-833

The economics of chemical brush control.

C. F. Sutherland

OREGON State University F-840

Primary productivity of red alder ecosystems.

J. Zavitzkovski

PENNSYLVANIA State University 1493

Soil-site evaluation for blackcherry and associated major species.

W. W. Ward

PENNSYLVANIA State University 1745

Revegetation of highly adverse sites created by coal mining.

R. J. Hutnik,

F. Y. Borden and W. W. Ward

SOUTH DAKOTA State University 452

Soil and vegetation of grasslands invaded by ponderosa pine.

J. T. Nichols

University of TENNESSEE 1

Growth of mixed species plantations.

E. Thor

University of TENNESSEE 4

Forest management determinants.

G. R. Wells

TEXAS A & M University 1673

Intensive culture of hardwoods.

R. G. Merrifield

University of VERMONT 2

Effect of leader damage on growth of planted conifers.

T. L. Turner

University of VERMONT 10

Influence of environment on chemical weed suppression in Christmas tree plantations.

T. R. Flanagan and M. L. McCormack

VIRGINIA Polytechnic Institute 350061

Resource use in the Southeastern logging industry.

D. P. Richards

University of WASHINGTON 6

Ecology and physiology of Douglas-fir and true firs.
D. R. M. Scott

WASHINGTON State University 1771

Genetics of multinodalness in lodgepole pine.
R. M. Dingle

WEST VIRGINIA University 5

Growth and yield of hardwoods. D. L. Kulow

University of WYOMING 940

The variation and ecology of aspen. A. A. Beetle

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IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF TREES

Research Problem Area 301.

Forestry research in this problem area extends from seeds to mature trees and includes tree breeding and genetics. Because of the diminishing land base of forest resources, much new research attention is devoted to development of trees that grow rapidly and exhibit greater resistance to destructive agents.

COLORADO State University 311

Genetic Potential of Rocky Mountain tree.

G. H. Fechner

An average set of 2.2 sound seeds per cone was obtained from blue spruce pollen on an Engelmann spruce mother tree; the reciprocal cross on a single blue spruce failed, suggesting low compatibility. The mean cotyledon number of the Engelmann spruce x blue spruce putative hybrid seedlings (5.4) did not differ significantly from that of the female parental progeny (5.8); however, both differed significantly from the blue spruce intraspecific progeny (7.2). Hypocotyl color of the putative hybrids was green, as was that of the Engelmann spruce intraspecific progeny; that of the paternal blue spruce progeny was red. One-fourth of the putative hybrid seedlings exhibited abnormal germination, the cotyledons alone emerging from the seed coat.

Local variation in morphological characters was observed in natural stands of Engelmann spruce and blue spruce. Cone length of Engelmann spruce varied from 26.0 mm. to 61.9 mm.; that of blue spruce, 44.0 mm. to 107.9 mm. Furthermore, on two altitudinal transects, most of the trees at 10,000 feet altitude had pubescent branchlets, and nearly all trees at 7,500 feet altitude had glabrous branchlets. On a third transect, however, the reverse pattern was observed.

Four cuttings each of 18 poplar clones were planted in artificial media controlled at each of five pH levels, 4.0 to 8.0. Preliminary analysis of shoot elongation did not reveal obvious effects of pH on early development, but clonal differences in survival and growth were pronounced. Greatest shoot weight per unit of original stem cutting weight developed in NE-17 (0.72) and NE-285 (0.70); these two clones also produced the greatest root weight per unit of original cutting weight (2.62 and 2.84, respectively). Both clones survived 100 percent for the duration of the study.

University of GEORGIA 14

Physiology and biosynthesis of oleoresin in Naval Stores pines.
C. L. Brown

Field studies were continued during May-Sept. 1968 on the application of different wounding techniques for intensive extraction of oleoresin in an attempt to lower costs of gum production. One treatment, utilizing simultaneous working of three faces, appears to hold some promise for future automation in that gum yields from individual trees during a three month period (June-Sept.) were comparable to the standard 8 month yields with bi-weekly chipping. Fig. 25 shows some wounding techniques.

Basic studies were continued on developing techniques for feeding and extracting labeled C^{14} precursors into needles, stems, and excised stem segments of slash pine in studies relating to biosynthesis of oleoresin. Resin exudation pressures were also monitored with electronic transducers for periods up to seven days at different points along the bole of large trees to gain an insight into the influence of water stress, temperature, and relative humidity on yields of oleoresin.



Figure 25. Application of various wounding techniques in studying the physiology of gum production in slash pine (*P. elliottii*). University of Georgia 14.

University of IDAHO 3

Heritability and population structure of ponderosa pine.
C. W. Wang

For the heritability study of ponderosa pine, 97 crosses and reciprocal-crosses were made in a 10-tree diallel cross. No pollen influence on seed characters was observed. However, 1-0 seedlings of selfings, 1-parent progenies, and pairs of reciprocal crosses indicated distinct between-progeny differences in cotyledon number.

Inter-ecotypic hybridization was made in crosses of *Pinus ponderosa* (N. Idaho) X *P. p.* (coastal Oregon), and *P. p.* (N. Idaho) X *P. p.* var *arizonica* (Arizonica). Seedlings were raised for the study of growth rate, early root development, frost and drought resistance, and photoperiodic responses.

For the population study, a range-wide survey was completed. Samples from natural stands were collected in 16 Western States and British Columbia.

Observations were made on the cone and seed characters, and morphology and anatomy of needles. Current works concentrated on, (1) growth chamber study of variations in germination temperature and early root extension, and (2) progeny test of the approximately 1000, 1-parent seed sources.

University of ILLINOIS 55-360

Soil moisture stress and growth and wood, loblolly pine.
A. R. Gilmore

Soil moisture was controlled in an 18-year-old loblolly pine plantation in southern Illinois so that the trees were subjected to drought conditions in the spring and field capacity during the summer. After four years of such treatment, terpenes were determined on gum samples collected biweekly at 1-, 11-, 21-, and 31-foot above-the-ground locations from stems of 21 trees. The most prevalent terpenes were alpha pinene, beta pinene, myrcene, camphene, and limonene in that order of concentration, regardless of position on the stem. There appeared to be a linear relationship between stem height and alpha and beta pinene concentrations; alpha pinene decreased with increasing height on the stem, whereas beta pinene increased up the stem. The other terpenes did not seem to be affected by stem position. Tentative results indicate no correlation between soil moisture stress and terpene composition. Work is continuing on this phase of the project and may provide some clue to possible relationships between terpene content and susceptibility to insect attacks.

University of MAINE 5002

Factors affecting growth of commercial forest tree species in Maine.
C. E. Schomaker

Field and greenhouse research are being used to investigate factors that affect the growth and distribution of forest trees in Maine. One hundred mature white pine were sampled in southern and central Maine and the concentration of 11 nutrient elements in the foliage were correlated with diameter and height growth. N, K, and Mg concentrations were positively correlated with growth. A study of vegetational transition and soil morphogenesis up Saddleback Mountain, Maine, found that an increase in the percent stand composition of balsam fir occurred with elevation, with increasing soil acidity, and with decreasing available soil moisture. In Northwestern

Maine, a study relating soil properties to selected stand characteristics of balsam fir found that the proper balance between soil moisture and aeration is critical for good balsam fir development. Basal area growth rate increases as pH of the A₂ horizon increases.

Nutrient research using white pine seedlings in a sand culture has shown a significant relationship between foliar nutrients and seedling growth when both available water and nutrient solution concentration were varied simultaneously. Possible antagonistic relationships between macro and micro-nutrients were also demonstrated. Greenhouse studies using white spruce, red spruce, and balsam fir seedlings are still underway as shown in fig. 26.



Figure 26. Effect of varying nitrogen on the growth of white pine seedlings. Pot N1 has the highest concentration of Nitrogen and potassium—N9 has the lowest. University of Maine 5002.

University of MICHIGAN 10

Carbohydrate physiology of wood formation.
R. Zahner and F. W. Whitmore

Indoleacetic acid (IAA) stimulated the incorporation of sugar into walls of cambial derivatives of *Populus deltoides* Bartr. trees, but not into those of *Pinus sylvestris* L. Extracts of cambium and cambial derivatives from both species contained a substance similar to IAA in chromatographic characteristics and growth promotion of wheat coleoptiles. Cambial derivative cells of both species accumulated IAA rapidly in uptake experiments, but the metabolic products of

IAA were different. It is suggested that the differences in response to IAA in terms of cell wall synthesis may be related to reaction wood formation. This project was terminated during 1968.

MICHIGAN State University 979

Nutrition of tree seedlings. **G. Schneider**

Seedlings (1-0) of tulip-poplar (*Liriodendron tulipifera*) and black walnut (*Juglans nigra*) were planted in field and forest openings that varied in size and aspect. Site conditions modified and investigated were weed control, fertilizer, and wind protection. Environmental measurements included solar radiation, wind movement, soil moisture, air and soil temperature, precipitation, and relative humidity. One and two years after planting, seedlings growing on wind-protected sites had greater height growth, larger leaf area, and less foliage damage than those on unprotected areas. Tree height within forest openings was twice that of open field plantings. Fertilization did not show significant height and stem increment during this time period. Biomass and nutrient assay are now being conducted on sample seedlings.

MISSISSIPPI State University 1128

Studies of the nutrient cycle in forest ecosystems.
G. L. Switzer and L. E. Nelson

The rate of growth and nutrient accumulation by the biomass of these ecosystems generally parallels each other during the early phases of the sapling stage; e.g. during the fifth year of development, stand dry matter doubles as do the quantities of N, P, K, Mg, and S; Ca triples. The distribution of this accumulation also follows the development of the shoot system of the trees comprising the population (fig. 27). Apical elongation within the crown follows the order Middle>Upper>Lower>>Basal; Dry matter, Middle>>Upper and Lower>>Basal; Nutrient accumulation, Middle>>Upper>>Lower and Basal. Thus, during this phase of development, increments in nearly all characteristics are greatest in that portion of the shoot system which develops on the section of the primary axis produced in the previous year, i.e. past years height increment, designated here as the middle crown. The distribution of nutrients within the tissues of the biomass is fairly static during this period; Foliage 60%, Bark 25%, Wood 15%. However, the rate of change in the relative distribution of mass

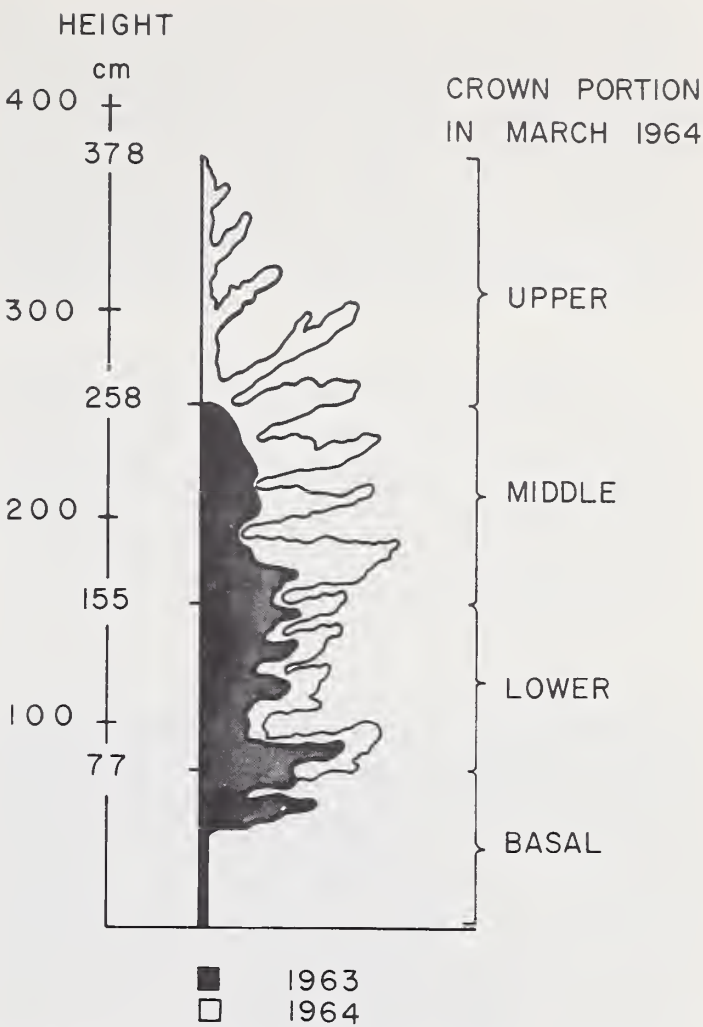


Figure 27. Nutrient accumulation follows the development of the shoot system. Mississippi State University 1128.

among these tissues during this period indicates a future change in distribution and importance of nutrient sinks; e.g. at the beginning of the period the ratio of support to productive tissue was 1.4 to 1.0; at the end 2.0 to 1.0 and for the tissues added, 2.6 to 1.0.

University of MISSOURI 607

Genetic investigations in forestation. **R. B. Polk**

Work started under this project is largely concerned with the genus *Pinus*. Objectives are directed toward the improvement of various pines for Christmas tree production, highway and other aesthetic forest plants, and windbreaks. Active experiments include provenance testing of Scotch, ponderosa, and jack pines; superior-tree selections of Scotch and jack pines, accompanied by progeny testing; and breeding studies with jack pine that include hybridizing with lodgepole pine followed by backcrossing of desirable first-generation hybrids to selected jack pine. Highly

inherent variation is being found among all of these species in such economically important traits as survival, growth, straightness, crown density, crown balance, foliage traits, and disease resistance. For example, although Scotch pine is not generally susceptible to the *Scirrhia* and *Dothistroma* needle-cast complex, certain otherwise desirable French and Spanish strains are highly vulnerable to these pathogens.

In the progeny testing of jack pine through controlled pollinations, it has been learned that this species is very responsive to selective breeding. Outstanding among the progenies obtained through the controlled breeding of selected parents are gains in straightness and growth rate as shown in fig. 28.



Figure 28. Eight-year-old jack pine in central Missouri, representative of a progeny from two parents selected for vigor, straightness of central stem, and crown symmetry. University of Missouri 607.

NEW YORK - State University College of Forestry at Syracuse University H

Biochemistry of seed dormancy. E. Sondheimer

Embryos removed from nondormant seeds will readily germinate within a day or two when placed on water, while those from dormant seeds will not. We found that these characteristics can be easily manipulated with certain hormones. A recently discovered plant growth regulator, abscisic acid, will inhibit germination of nondormant embryos while gibberelins will permit germination of nondormant specimens. Both effects are reversible. Even more interesting was the finding that dormant *Fraxinus* seeds contain rather high levels of abscisic acid and that the concentration of this hormone decreases very markedly during cold temperature after ripening. Additional experiments indicated that this drop in hormone level may be a determining factor in regulating seed dormancy. Experiments are presently underway which we hope will provide some insight into the mode of action of these hormones. For this work we are using excised bean axes where growth responses to the hormones are discernible very rapidly. A few hours after exposure to abscisic acid, growth inhibitions are observed. These are also reversed but in this case by another plant growth hormone, zeatin. Zeatin was first isolated from immature corn kernels but has biological activity in many different plants. The effects of these hormones on protein and nucleic acid syntheses are being studied and should provide new knowledge of significance to seed germination.

NORTH CAROLINA State University 4010

Physiological basis for genotype productivity. T. O. Perry

Several manuscripts have been completed and submitted for publication. The subjects covered were:

- 1) Estimation of photosynthetically active light under forest canopies using the breakdown of chlorophyll as a detection process.

- 2) Measurement of the photosynthesis, respiration, and dry matter production of deciduous trees during the winter.
- 3) Measurement of variations in phenol, fat, and enzyme content of different races of red maple in the dormant and vegetative state.

Research on the physiological bases of differences in productivity among genotypes continues. With the completion of the new phytotron, our studies of genetic and physiological aspects of dormancy have been accelerated. A joint paper with a former graduate student on seasonal differences in photosynthetic rate emphasizes the importance of the relationship between genetic differences in dormancy phenomena and productivity.

Photosynthesis and dry weight changes by dominant twigs and buds of the hardwood species *Liquidambar styraciflua* were measured as part of the investigation on the lack of correlation between genetic differences in photosynthetic efficiency per gram of leaf surface and genetic differences in dry matter production per

plant. The results are presented in fig. 29. The dry weight changes of a group of loblolly pine seedling were also measured for comparison. Each bar on the graph indicates the dry weight of the 30 seedlings on the date indicated. The leafless hardwood seedlings increased in dry weight by 42 percent from December 21 through April 1. The pines increased in dry weight by 68 percent during the same period.

NORTH CAROLINA State University 4011

Soil nutrient and seed source for optimum sweetgum plantations.
J. W. Johnson

No activity other than field plot maintenance was carried out for this report period. The first meaningful analysis of growth results is scheduled at the end of the third growing season after outplanting, or after the 1969 growing season. The sweetgum shown in fig. 30 is tall, straight, clean, and fast-growing. Will its progeny develop equally as well over a range of site quality conditions? Will these progeny respond to soil nutrient supplements? Project 4011 seeks answers to these questions.

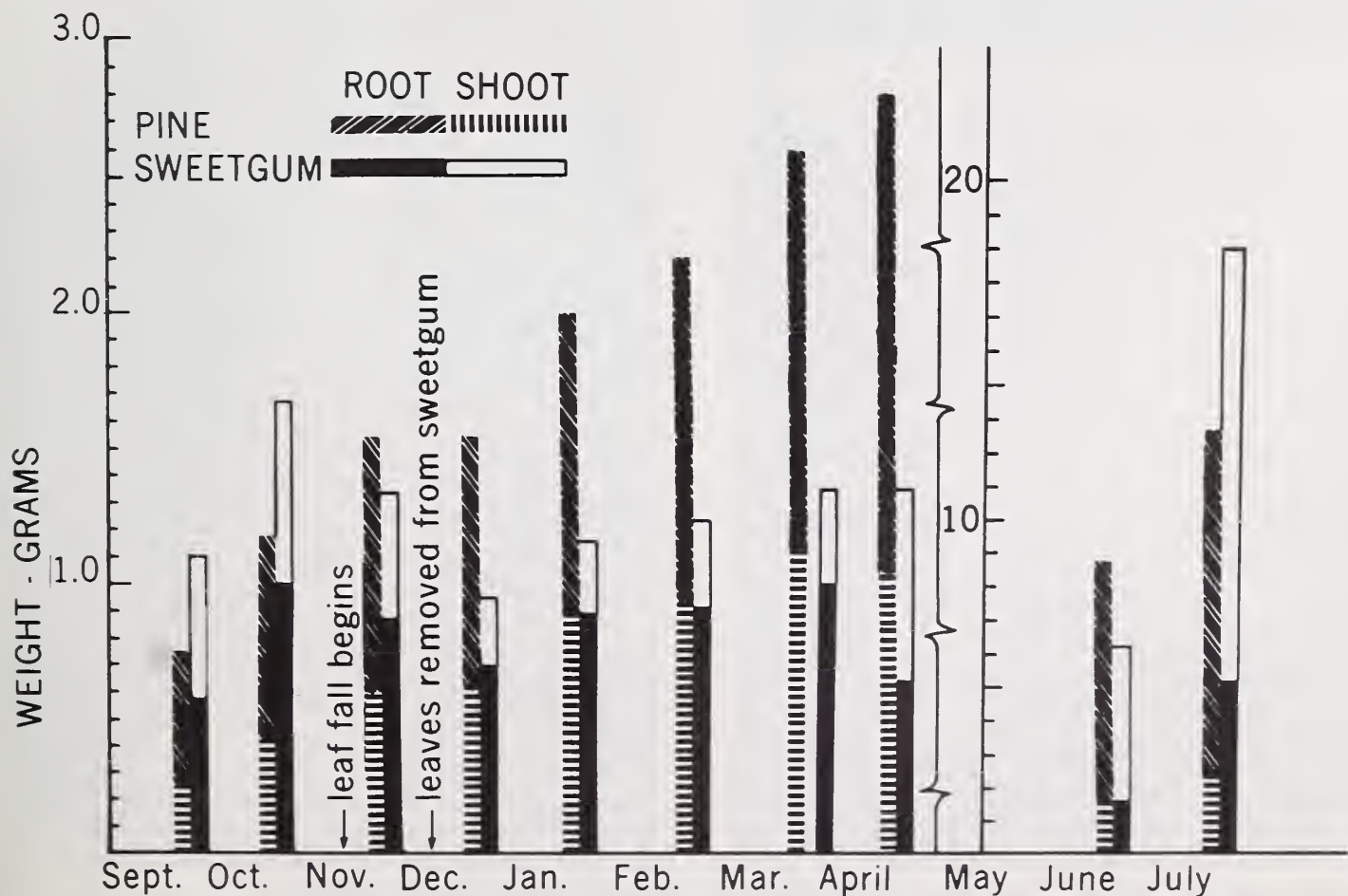


Figure 29. Differences in dry-matter production of *Liquidambar styraciflua*. North Carolina State University 4010.



Figure 30. This sweetgum is tall, straight, clean, fast-growing. Will its progeny develop equally as well over a range of site quality conditions? Will these progeny respond to soil nutrient supplements? North Carolina State University 4011.

OHIO Agricultural Research and Development
Center 5

Physiology of juvenile growth of trees. A. R. Vogt

This project is concerned with determining conditions in northern red oak which control its development through the early period of vegetative growth to a flowering, mature tree. Aspects of development studied this past year were acorn maturation, seedling development including height growth, leaf senescence and dormancy, mature tree bud dormancy, and propagation of cuttings. Emphasis has been on determining the role of plant growth hormones on these processes. Generally, attempts are made to invoke a response by the tree to hormonal applications followed by investigations which attempt to

identify the normal participation of similar groups of hormones produced in the tree.

A balance of gibberellins and gibberellin inhibitors appears to be one important hormonal system which determines whether a seed or bud will remain dormant. Dormant buds on oak seedlings or cuttings sprayed with gibberellic acid (GA_3) in late summer resume growth and clearly show increased stem elongation.

Red oak seeds normally require a period of cold, moist treatment before they will germinate. Applications of GA_3 to unchilled acorns partially replace this requirement and stimulate metabolic processes. Respiration is increased and germination is possible with far less chilling than is required by the controls. Conclusions are that cold treatment of acorns increases the relative ratio of gibberellins to their inhibitors, a condition necessary for germination. Seedlings which result from acorns treated with GA_3 are taller with smaller root systems and thinner leaves. Changes in naturally-occurring gibberellins and gibberellin inhibitors in the seed during the period of cold treatment are being measured. Knowledge from investigations on physiological requirements for seed germination and pregermination effects on seedling growth may be used to obtain more rapid, uniform germination of red oak into a seedling with predetermined growth characteristics.

Flower buds from a mature tree and juvenile seedlings were collected in the spring during the period that the buds were breaking dormancy. These tissues are presently being analyzed for changes in gibberellins and gibberellin inhibitors related to bud development. Attempts to "nurse seed graft" branches from mature trees on to germinating acorns were not successful last spring. This work is being continued in 1969. Successful grafting by these techniques would provide material with less genetical variation and enable more intensive environmental control in studies of hormonal relationships with flower initiation.

OKLAHOMA State University 1241

Clinal variation in shortleaf pine. C. E. Posey

Open-pollinated seed from 15 geographic sources within Oklahoma, kept separate by mother trees, was sown in 9 replications in the nursery. At the end of the first growing season, the seedlings were lifted and

outplanted at two locations. The plantings are too young to provide additional information. Based on observations of the seedlings in the seed beds, the following results were obtained. Variation in cotyledon number, cotyledon length, and number of stomatal lines on mature needles indicates that significant racial variation has occurred in shortleaf pine within Oklahoma. Seedlings from coastal plain sources were taller than seedlings from mountain sources. The fact that racial variation has occurred in shortleaf pine within Oklahoma substantiates the need for establishment of seed collection zones within the state. The results also indicate that more than one shortleaf pine seed orchard will be required to meet the future seed needs of the state.

Estimates of heritability were also computed for several traits. Heritabilities were based on one-year-old trees from wind-pollinated seed so the data, shown below, should be considered as estimates only.

Trait	Heritability
Cotyledon length	0.82
Cotyledon number	1.00
Number of stomatal lines	0.32
Number of limbs	0.34
Seedling height	0.48

OKLAHOMA State University 1304

Improved loblolly and shortleaf pine. C. E. Posey

During the last grafting season, approximately 3,000 grafts were made. The grafts that survived have been transplanted into the field. Rootstock for grafts to be made in the spring have been established. Through cooperation with Dierks Forests, Inc., International Paper Company, and the U.S. Forest Service, sixty-seven select shortleaf and loblolly pine trees have been evaluated and accepted into the breeding pro-



Figure 31. Genetic differences in crown shape on the Songeregger pine plantation. A. Wide crown after 4 growing seasons. B. Narrow crown after 4 growing seasons. Clemson University 704.

gram. Approximately 40 acres of breeding orchards have been established. Additional facilities for tree breeding work in the form of a greenhouse and laboratory equipment have been built or purchased.

SOUTH CAROLINA - Clemson University 704

Genetics of forest trees.

R. E. Schoenike

Thirty-two grafts representing nine clones of selected loblolly pines were made in April and were placed in the seed orchard during November. Total number of living grafts is now 212; 450 are anticipated when the orchard is complete. Flowering has begun on three clones. Continued evaluations of yellow-poplar superior tree selections has reduced the number from 65 to 52. It is planned to eventually work with 35 clones. Eastern redcedar seed source plots have been measured and await analysis. Survival is good. Deodar

cedars representing 15 progenies were released from competition. No analysis to date but trees planted in a forest stand are growing better than those on an old field. The Sonderegger pine plantation was recleaned. Early evaluation has revealed striking differences in crown form (fig. 31) among 4-year old trees. Trees have shown no signs of fruiting thus far. Twenty aberrant loblolly pine seedlings were planted on an old field site on the Clemson Forest where they will be kept for future observation and study.

University of VERMONT 11

Physiological mechanisms responsible for sap flow in sugar maples.

J. W. Marvin

Maple roots were grown successfully in the summer of 1968 in a Rhizotron (fig. 32). These root systems, excised from the parent plant, are being used in the



Figure 32. Successful root development in a Rhizotron. University of Vermont 11.

laboratory under controlled conditions, to study the effect of cycling temperatures on the absorption of water and on sap flow. A technique has been developed to study and separate the several mechanisms involved in maple sap flow. Small sections of maple stems (3-6 gms.), after an initial flow has been induced and measured in the laboratory, are perfused with one of a number of solutions and again heated with a sap flow inducing temperature cycle and the effect of the perfusate on the flow observed. The results of these experiments are contributing to an understanding of the temperature sensitive mechanisms responsible for solute and water movement in stems, and maple sap flow in particular.

WEST VIRGINIA University 1

Selection, propagation, and silvicultural regeneration of genotypes of hardwood tree species. F. C. Cech

A 4-acre plantation was established with seedlings from the 1967 seed beds. Initial survival was poor, and replanting will be done where excess stock is available. Seed from 38 sources (252 trees) was planted. Germination was fair but enough seedlings are available to make 10 plantations including 22 sources. Arrangements have been made to send plantings to cooperators in 6 states and Canada in addition to two plantations to be established in West Virginia. Greenhouse-planted cherry seedlings were washed and root and top growth measurements made. The data are being prepared for analysis. Electrophoresis technique, developed for isoenzyme analysis, on dormant seed of black cherry was initiated. Several methods and modifications have been tried. Good spectra have been found, but modifications are being made of the most promising technique in order to break down one especially heavy band. The yellow-poplar seed stimulation plots were limed and fertilized. Herbicide was applied to the fertilized area of all but control trees. Total height and d.b.h. measurements were made. Seed heads were counted and detailed soil samples and foliage samples were collected.

ADDITIONAL PROJECTS

ALABAMA - Auburn University 901

Within-tree variation in cell anatomy. J. F. Goggans

ALABAMA - Auburn University 903

Improved forest trees for Alabama. J. F. Goggans

ALABAMA - Auburn University 905

Anatomy of figured wood. H. O. Beals

CALIFORNIA - Humboldt State College 9

Transpiration reduction of transplanted coniferous forest seedlings. D. Thornburgh

CALIFORNIA - Humboldt State College 11

A provenance study on Coast redwood. D. Thornburgh

University of DELAWARE 759

Nutrition of holly understory. C. W. Dunham

University of FLORIDA 1210

Nitrogen nutrition and reproduction of slash pine. R. G. Stanley and W. H. Smith

University of FLORIDA 1250 SL

Water control for forest production. W. L. Pritchett and R. E. Choate

University of FLORIDA 1293

Stock-scion relationships of Southern pine. W. H. Smith

University of GEORGIA 17

Crown growth and wood formation in loblolly pine. J. R. Beckwith

University of GEORGIA 22

Quick coppicing hardwoods for fiber yield. C. L. Brown and J. T. May

University of IDAHO 2

Elongation and activity of roots of coniferous seedlings as determined by radioactive tracers. H. Loewenstein

University of ILLINOIS 303

Internal moisture balance, photosynthesis-respiration ratios; and tree development. W. R. Boggess

INDIANA - Purdue University 1476

Establishment and culture of black walnut, tulip-poplar, and cottonwood. W. R. Byrnes

IOWA State University 1582

Photosynthesis, respiration and growth of seedlings of two Iowa-grown forest tree species. G. E. Gatherum

University of MAINE 5006

Nutrients and weight of complete trees. H. E. Young

University of MARYLAND L-100

Vegetative propagation of pine by needle fascicles. J. B. Shanks

University of MASSACHUSETTS 9

Maple tree root initiation, development and geotropic response. B. F. Wilson

University of MICHIGAN 1

Techniques for use of $C^{14}O_2$ to tag current photosynthate in studies of phloem transport in forest trees. R. Zahner

University of MICHIGAN 8

Biosystematics of birch complex. B. V. Barnes

University of MICHIGAN 12

Vessel length in angiosperm xylem. R. Zahner

MICHIGAN State University 936

Mineral nutrition of trees related to genetic variation. J. W. Hanover

MICHIGAN Technological University 2-3011

Genetic improvement of sugar maple. R. L. Sajdak and P. W. Garrett

MICHIGAN Technological University 7

Soil-site in Northern hardwoods. S. G. Shetron

University of MINNESOTA 19-78

Hybridization studies in populus. S. S. Pauley

MISSISSIPPI State University 1122

Multinodal growth shoot systems in loblolly pine plantations in conifers of multinodal growth habit. W. W. Elam

University of MISSOURI 534

Moisture in the artificial pollination of pines. R. Polk

University of MISSOURI 606

Responses of protein synthesis to environmental stresses and resultant morphological changes. G. N. Brown

University of MONTANA 210-904

Hybridization of western and sub-alpine larch. G. M. Blake

University of MONTANA 210-1801

Nutrient culture of Western larch. M. J. Behan

University of NEBRASKA 20-28

Tree breeding. W. T. Bagley

University of NEW HAMPSHIRE 1

Cultural practices for balsam fir Christmas tree production. P. E. Burns

NEW JERSEY - Rutgers University 245

Juvenile-to-mature red oak. C. E. Hess

NEW YORK - Cornell University 905

Effect of soil fertility on forest ecology and growth. E. L. Stone

NEW YORK - State Univ. College of Forestry at Syracuse Univ. B.

Wood properties of 35-year old red pine plantations supported by potash depleted soils. C. de Zeeuw

NEW YORK - State Univ. College of Forestry at Syracuse Univ. F.

Variability in wood quality in forest trees. W. T. Gladstone

NEW YORK - State Univ. College of
Forestry at Syracuse Univ. G.

*A study of the deposition of arabinogalactan in larch
wood.* T. E. Timell and W. A. Cote, Jr.

NEW YORK - State Univ. College of
Forestry at Syracuse Univ. L.

Chemistry of aquatic plants. R. T. LaLonde

NORTH CAROLINA State University 4004

*Tree stem movement, form, and strength properties
in loblolly pine.* J. W. Duffield

NORTH CAROLINA State University 40016

Taxonomic relationship of P. rigida and P. serotina.
L. C. Saylor

NORTH CAROLINA State University 40018

Fertilization and irrigation of seed orchards.
C. B. Davey

OHIO Agricultural Research and Development
Center 1

Effects of fertilizers on sugar maple and tulip-poplar.
J. P. Vimmerstedt

OHIO Agricultural Research and Development
Center 2

*Seed development in white pine in relation to sterility
barriers, inbreeding depression and hybrid vigor.*
H. B. Kriebel

OHIO Agricultural Research and Development
Center 6

Physiology of the formation of wood in oak and pine.
F. W. Whitmore

OKLAHOMA State University 1234

Pot tests of selected trees and soil types.
T. Q. Lynd and T. H. Silker

OKLAHOMA State University 1332

*Metabolism and movement of herbicides in woody
plants.* E. Basler, Jr.

OKLAHOMA State University 1348

Evaluation of shortleaf x slash pine hybrids.
C. E. Posey

OKLAHOMA State University 1349

Cottonwood improvement. C. E. Posey

OREGON State University F-759

Inter- and intra-family variation in Douglas-fir.
H. Irgens-Moller

OREGON State University F-760

*Cooperative development of Douglas-fir seed from
high and low elevation trees.* W. P. Wheeler

OREGON State University F-762

Flower induction on juvenile Douglas-fir.
K. K. Ching and D. P. Lavender

OREGON State University F-786

Structural variation in Douglas-fir bark.
R. L. Krahmer

OREGON State University F-794

Transpiration of Douglas-fir seedlings. W. K. Ferrell

PENNSYLVANIA State University 1487

*Fertilization of forest stands for timber and wildlife
food production.* W. W. Ward

PENNSYLVANIA State University 1805

*Stochastic models for simulation of even-aged forest
stand systems.* P. E. Dress

SOUTH CAROLINA - Clemson University 705

Inbreeding in Virginia pine. R. E. Shoenike

SOUTH CAROLINA - Clemson University 708

Effect of moisture stress on rates of photosynthesis.
W. H. D. McGregor

SOUTH CAROLINA - Clemson University 709

X-Ray examination of seed embryos.

W. H. D. McGregor

SOUTH CAROLINA - Clemson University 717

Variation and tree improvement studies in the genus quercus.

R. E. Schoenike

SOUTH CAROLINA - Clemson University 789

Fertilization and irrigation on upland forest.

W. H. D. McGregor

SOUTH CAROLINA - Clemson University 853

Mechanisms controlling gas exchange of detached pine needles.

R. M. Allen

SOUTH CAROLINA - Clemson University 881

Variation and inheritance of longleaf pine.

O. B. Garrison

University of TENNESSEE 2

Fertilization and irrigation effects on tree growth.

E. R. Buckner

TEXAS A & M University 1527

Silvical requirements for optimum development of loblolly pine.

R. R. Rhodes

TEXAS A & M University 1649

Water stress and growth in loblolly pine.

D. M. Moehring

UTAH State University 658

The production of essential oils from the Pinyon-Juniper type.

W. H. Johnson

University of VERMONT 9

Light and internal moisture of beech seedlings.

B. W. Post

University of VERMONT 12

Role of cell transitions in the physiology of some Northern hardwoods.

J. W. Marvin

VIRGINIA Polytechnic Institute 350031

Parameters of site for certain tree species in Virginia.

H. A. I. Madgwick,

R. Stemple and J. F. Hosner

VIRGINIA Polytechnic Institute 350081

Synthesis of ribonucleic acid and development of the ribosomal system.

R. E. Adams and L. B. Barnett

University of WASHINGTON 1

Effect of nitrogen on growth of Douglas-fir.

S. P. Gessel and T. N. Stoute

University of WASHINGTON 16

Genetic studies of Pacific Northwest hardwoods.

R. F. Stettler

University of WASHINGTON 18

Biosynthesis of Maltol.

B. F. Hrutfiord

University of WISCONSIN 1262

Cross and self-incompatibility in trees.

D. T. Lester

University of WISCONSIN 1350

Metabolic antitranspirants on trees.

T. T. Kozlowski

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NEW AND IMPROVED ENGINEERING SYSTEMS

Research Problem Area 302.

Forestry research in this area ranges from cost reduction for tree harvesting to research on new engineering techniques for wood processing. Additional research strongly related to these problems occurs in problem areas 303, 401, and 512.

University of CALIFORNIA - Berkeley 2181

A study of the wood machining process.

J. D. Cumming

A three component dynamometer was designed to measure three dimensional cutting forces as well as axial symmetric cutting such as drilling and to have linear response with minimum interaction between force components. A method was developed to calculate principal strains, principal directions, rotation and dilatation from uniform or non-uniform grid distortion patterns of strain fields in wood machining. Both incremental strains and strain rates can be calculated. An eight point least squares statistical estimate of the parameters is used. Comparison of model veneer slicing studies at slow speeds with prototype rotary veneer cutting showed similar trends with cutting parameters. Surface roughness measurements were considerably shorter and check frequency lower for the model study. It appears that cutting velocity may account for this difference which requires further study. Twenty-one cutting variables are involved in band sawing. The effect and interactions of these variables in sawing a surface of specified dimension, straightness and surface quality have been examined. Tooth bite was found to be the

most important parameter, when cutting dry (8%EMC) incense cedar. Machining variables in chip formation are shown in Figure 33.

ADDITIONAL PROJECTS

University of CALIFORNIA - Berkeley 2538

Economic analysis of wood procurement systems.

W. McKillop

LOUISIANA State University 1444

The development of timber harvesting systems for the Gulf South.

R. W. McDermid

MICHIGAN Technological University 4

Logging survey in Lake States.

V. G. Smith

MICHIGAN Technological University 5

Pulpwood skidding time analysis.

H. M. Steinhilb

NORTH CAROLINA State University 4017

Survey of pulp and paper mill effluent control and treatment.

C. N. Rogers

SOUTH CAROLINA - Clemson University 707

Logging cost studies.

W. A. Shain

University of WASHINGTON 7

Timber harvesting in Pacific Northwest second growth stands.

G. Stenzel

PUBLICATIONS

Cumming, J. D.

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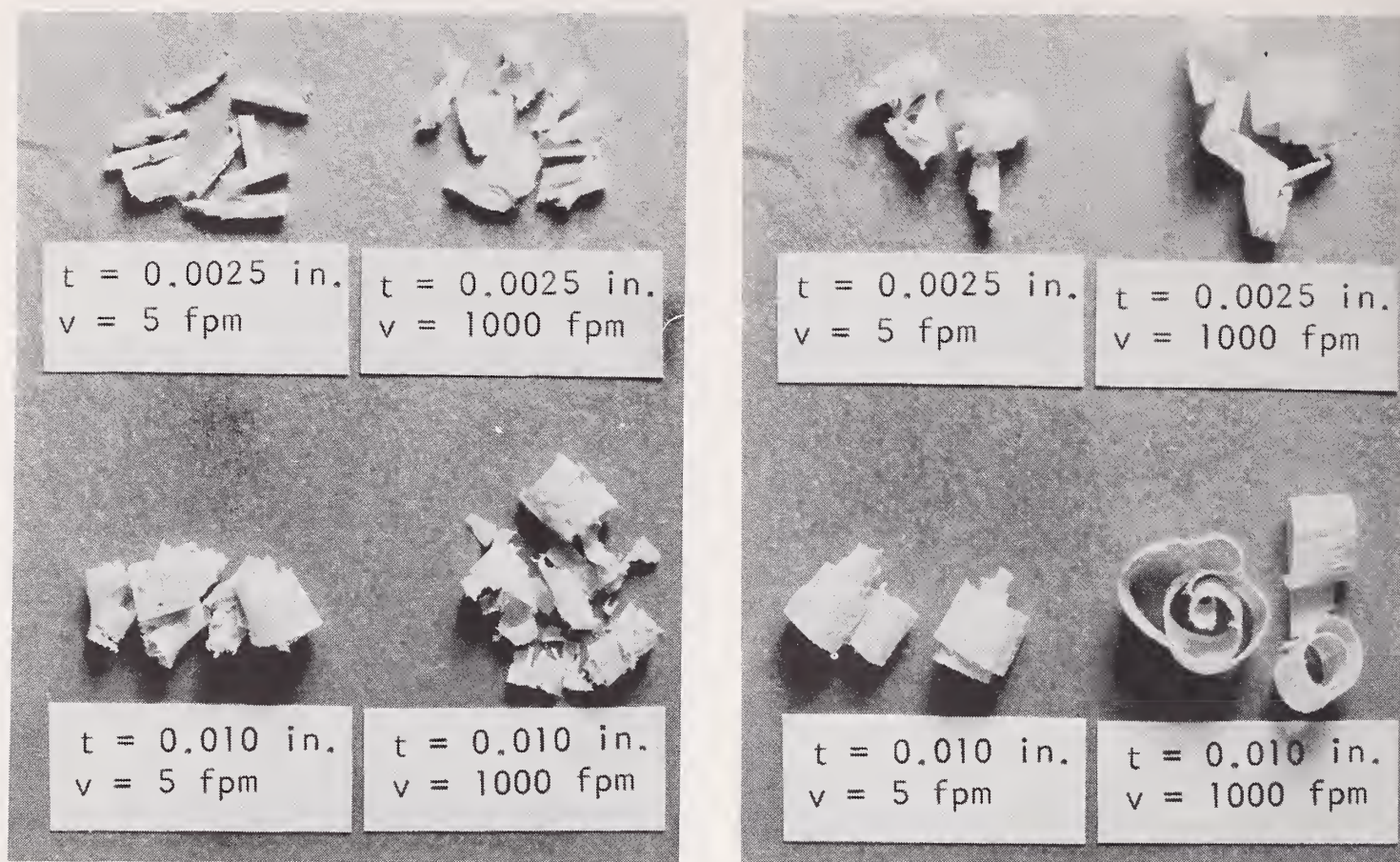


Figure 33. Effect of machining variables on chip formation: Douglas Fir chips – grain angle 5°; left picture: 6% moisture–10° cutting angle; right picture: 18% moisture–30° cutting angle. University of California - Berkeley 2181.

Cumming, J. D. and G. S. Gill.

Temperature Gradients and Thermal Stresses
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No. 2: 86-92.

McKenzie, W. and J. D. Cumming.

Coordinating Photographic and Instrument
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Forest Products Journal. Vol. 18, No. 12: 53.

ECONOMICS OF TIMBER PRODUCTION

Research Problem Area 303.

The economic variables in all phases of timber production are the source of constant study in order to furnish the land manager with non-biological decision-making tools that will justify biological manipulation prior to processing. Computer techniques derived from careful systems analysis receive increasingly more attention.

University of CALIFORNIA - Berkeley 2349

Determination of optimum forest production schedules by mathematical programming.

D. E. Teeguarden

Alternative linear programming models for planning management activities on a case forest were constructed and tested. The models define relationships between program value, alternative timber harvesting and land management activities, resource availability, and policy constraints. For each of 75 type-condition classes, alternative treatments over a 20-year period were defined. Nearly 2,000 activity variables were included. Constraints were imposed on minimum cash-flow requirements, areas harvested by four 5-year periods, areas precluded from harvesting, area clear-cut. Optimal management programs were computed with three assumptions regarding an effectiveness criterion: (1) total volume cut plus ending inventory; (2) nondiscounted cash-flow plus ending inventory value; and (3) discounted cash-flow plus ending inventory value. Nine alternative assumptions concerning stumpage prices and discount rate were studied through computer simulation. Preliminary analysis indicates that maximizing the volume or undiscounted value of cut plus ending inventory give similar programs for the case forest. Limiting is the minimum cash-flow requirement. For other objectives solutions are constrained by cutting policies. Parametric tests will be made to explore sensitivity of the program to these and other constraints.

ADDITIONAL PROJECTS

University of CALIFORNIA - Berkeley 2447

Financially optimum thinning regimes for mixed-conifer forests of California. R. F. Grah

University of CALIFORNIA - Berkeley 2505

The role of Oligopsony and Monopoly in markets for publicly owned timber in California. H. J. Vaux

University of GEORGIA 19

Cash flow and forest management policy as related to income and taxes. J. L. Clutter

LOUISIANA Polytechnic Institute 6

Workmen's compensation and safety in timber harvesting and wood-using mills, Arkansas and Louisiana. E. J. Carothers

University of NEW HAMPSHIRE 2

Application of mathematical programming models to planning over time in the large forest firm.

B. B. Foster

University of VERMONT 14

Forest management by parametric linear programming. F. Armstrong

PUBLICATIONS

A Modified General Simplex Method for Solving Linear Programming Problems, by Bennett B. Foster and Richard R. Weyrick, Station Bulletin 493, Agricultural Experiment Station, University of New Hampshire, Durham. 24 pages.

Chapter 4

FOREST PRODUCTS AND MARKETING

Housing Research

Program Element 669

Forestry research on housing is directed toward the clarification of wood properties that are peculiarly adaptable to residence requirements. A national need exists for more and better housing for low-income families, including the elderly, migrant workers, and rural poor.

HOUSING NEEDS OF RURAL FAMILIES

Research Problem Area 801.

Research in the states has been focused on sound insulation, heat and moisture transfer, and on the development of wood and wood component structural systems. Another area of research embraces termite control.

ALABAMA - Auburn University 910

Strength of plastic-overlaid pine plywood and particleboard.

E. J. Biblis

Results of flexure testing of control 3-ply and 5-ply southern pine plywood and unidirectionally lami-

nated veneer specimens reveal the following conclusions: The percentage of midspan shear deflections at the proportional limit load of 3-ply southern pine plywood ($1/10 + 1/8 + 1/10$ in.) with face grain parallel-to-span at a 14:1 span-to-depth ratio is slightly greater than deflection caused by pure bending. The relationship of shear deflection to pure bending deflection is shown in fig. 34.

In 5-ply plywood ($1/10 + 1/8 + 1/10 + 1/8 + 1/10$ in.) with face grain parallel-to-span and at a 14:1 span-to-depth ratio, the shear deflection is approximately 40 percent of the total. Average midspan shear deflections at the proportional limit loads of southern pine plywood with face grain parallel-to-span at 48:1 span-to-depth ratio are 7.5 and 5.1 percent for the 3-ply and 5-ply respectively. This

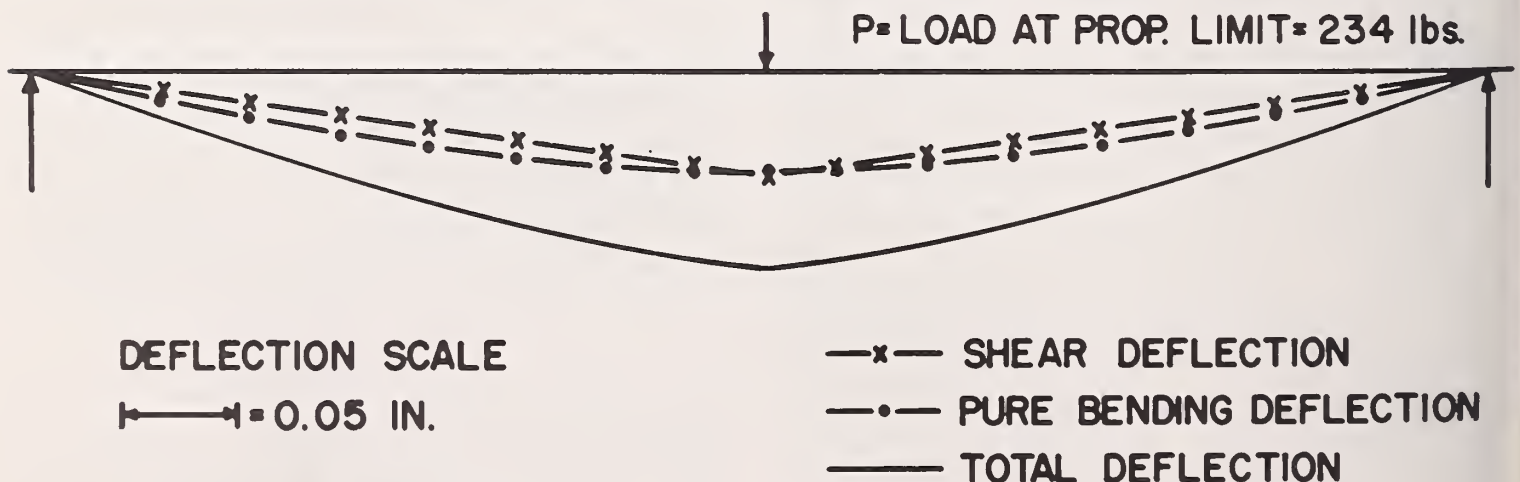


Figure 34. Elastic curves of 3-ply (0.325 in.) Southern Pine plywood flexure specimens at 14:1 span-to-depth ratio. Auburn University 910.

finding is especially important since ASTM standard D805-63 specifies a 48:1 span-to-depth ratio for testing plywood without indicating the degree of purity of the effective E obtained. The pure E of 3-ply and 5-ply southern pine plywood with face grain perpendicular-to-span was only 8.1 and 33.9 percent respectively of the pure E corresponding to similar plywood with face grain parallel-to-span. Flexure modulus of elasticity and percentage of shear deflection of 3-ply southern pine plywood at span-to-depth ratios 48:1, 24:1, and 14:1 were predicted by two theoretical methods and compared with values from actual tests. One method suggested by H. W. March was based on theory of anisotropic elasticity. The other method was based on transformation of the rectangular cross section of 3-ply plywood strip to a cross section of an I-beam. Both methods predicted values which were in excellent agreement with actual values from tests.

IOWA State University 1650

Causes and severity of wood use problems in residential construction in Iowa. D. R. Prestemon

This study was designed to identify and analyze important wood-use problems and investigate status and trends in marketing wood building materials. An initial survey of 125 Iowa home builders focusing on construction practices and wood-use problems in residential construction gave the following results for 1955: (1) one-fifth of the homes were built using prefabricated wall components and 41 percent of the homes featured roof trusses; (2) wood or fiberboard siding was used on 85 percent of the homes; (3) three-fourths of the homes featured wood finish floors in the bedrooms and about 1/2 of the homes featured wood floors in the living rooms; (4) 80 percent of the contractors used some wood paneling in their homes; (5) wood-use problems identified by builders and ranked in order of importance were: shrinkage and warp, high prices, poor quality, finishing difficulties and high installation costs. Purchasing practices of Iowa home builders were investigated in another survey of 280 firms active in residential construction in 1966. Important results of this survey on purchasing practices were: (1) more than half of the lumber, plywood and insulation board used in residential construction during 1966 was purchased from retail sources; (2) builders constructing a small number of large homes most frequently patronized retailers while large volume builders purchased from a

variety of sources; (3) builders bought a smaller proportion of materials from retailers in 1966 than in 1962 and an even smaller amount will be purchased from retail sources in the future; (4) best combination of price and quality and prompt and dependable delivery service were the two factors rated as most important to builders in deciding where to buy building materials for residential construction.

ADDITIONAL PROJECTS

ALABAMA - Auburn University 902

Wood aggregates in concrete products. E. J. Biblis

University of GEORGIA 15

Technology of exterior grade building components made from wood-glue composites. J. T. Rice

INDIANA - Purdue University 1353

Analytical design of wood trussed rafters. S. K. Suddarth

IOWA State University 1744

Assessing consumer preferences for housing. D. R. Prestemon

University of KENTUCKY 1015

Use of Appalachian lumber. J. N. Walker

University of MAINE 5004

Maine wood properties and grades for product utilization. J. E. Shottafer and T. J. Corcoran

University of WASHINGTON 9

A study of the surface properties of wood as related to wood adhesion. B. S. Bryant

PUBLICATIONS

Biblis, E. J. and Cheng-Fan Lo.

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1968 *Potential production: Plywood from Eastern spruce.* Forest Products Journal. Vol. 18 (10).
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1968 *The influence of cyclic drying on machining defects.* Proc. N.E. Section Forest Products Research Society. 23-24. University of Maine.

Forest Products Marketing Research

Program Element 695

The basic goal of marketing research is to increase the income of forest owners and wood processors and to provide consumers with better products at lower costs. Research results furnish a means to evaluate opportunities for market expansion and to develop grades and standards that better characterize a product.

DEVELOPMENT OF MARKETS AND MARKETING EFFICIENCY

Research Problem Area 502.

Research in this problem area is devoted to timber as well as to wood products. Timber marketing research is aimed at overcoming the economic inequities that result in a poorly developed marketing system caused by the frequency of small ownerships and by the relative infrequency in which owners have timber for sale. For wood products, much research is directed toward market expansion occasioned by new and unique wood products.

ALABAMA - Auburn University 906

Availability and potential uses of hardwoods degraded by microorganisms.

T. C. Davis and H. O. Beals

Results of additional samplings of degraded wood in Alabama confirm previous findings. Further examina-

tion of inoculated logs and living trees confirm that logs can be inoculated successfully with *Stereum frustulosum* and *Stereum subpileatum*. Inoculations of heartwood within living trees were unsuccessful, probably because drill wounds were calloused over by additional tree growth. Only slight pocket decay within inoculated logs was present 2 years after inoculation and this appeared to be confined largely to central portions of logs. Presence of the two fungi within various regions of inoculated logs appeared to be very irregular. Evidence suggests that conversion of oak wood to partridge wood or pheasant wood in nature probably is a long term process, perhaps requiring 5-10 years or more (depending upon environmental conditions). Several additional novelty type items were constructed from pheasant wood. Small ornamental figurines of this wood are highly desirable from the esthetic standpoint, but are very fragile along thin cross-sections in certain designs. Companies and individuals interested were provided with samples of various degraded woods. The photo of the picture frame (fig. 35) does not reveal the interesting color patterns in this degraded wood.



Figure 35. Partridge wood used in early American style frame. Different degrees of decay and color are represented in veneered sections. (Oil painting by Glen Hefner) Auburn University 906.

University of ILLINOIS 310

A survey of secondary wood-using industries.

I. I. Holland

Four hundred and twenty-eight firms located primarily in central and northern Illinois constitute the secondary wood-using industries of Illinois (excluding furniture, construction, and pulp and paper products). The mill work industry (47%), sawmills manufacturing secondary wood products (10%), miscellaneous wood products plants (10%), and the partitions and fixtures industry (17%), combined, account for almost 85 percent of all firms. Seventy-two percent of all firms have fewer than 20 employees, and most technical and production problems stem from small firm size. In 1966, it is estimated that these industries used about 180 million board feet of hardwood and 90 million board feet of softwood lumber, 12 million square feet of hardwood and 30 million square feet of softwood plywood, and 21 million square feet of hardboard making Illinois one of the most important users of these materials in the U.S. Practically all of the important kinds of lumber (pine, fir, oak, walnut,

birch, maple, poplar) and plywood (Douglas-fir, birch, walnut, oak) is, and for some time must continue to be, supplied from outside Illinois. Not until better forest management of the state's timber resource is accomplished can the primary wood products supply the materials needed by secondary wood users. In the interval, much more attention through research and communication must be given the solution of the technical, production, and labor problems of these industries. Mainly because of small size, inadequate primary and technical incompetence, a majority of these firms encounter inefficiencies in inventory control, materials handling, plant layout, machining, quality control, and finishing.

ADDITIONAL PROJECTS

University of CALIFORNIA - Berkeley 2357

The marketability of veneer and plywood from young-growth California pine and redwood.

F. E. Dickinson

KANSAS State University 670

Marketing of forest products.

W. A. Geyer

LOUISIANA State University 1233

Lumber distribution patterns in Louisiana.

P. J. Fogg

University of MARYLAND A-26

Forest market structure.

R. F. McDonald

MICHIGAN State University 980

Hardwood utilization and marketing.

L. James

University of MONTANA 202

Marketing Montana lumber.

R. W. Wambach

NEW YORK - State University College of Forestry at Syracuse University K

Aesthetic reactions to forest scenes.

W. D. Wenger, Jr.

University of TENNESSEE 8

Christmas tree breeding.

E. Thor

Requirements and distribution of wood products manufactured and used in Texas. H. B. Sorenson

PUBLICATIONS

Gunter, E. R. and E. L. Klein.

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Rawlins, N. O., H. B. Sorensen and J. C. Grady.

Production, marketing and prices of Southern pulpwood. DIR 68-1 Texas Agricultural Experiment Station 1-43 pp.

McDonald, R. F.

Market structure of the sawmill industry. 1968 Misc. Pub. 645 Agricultural Experiment Station, University of Maryland.

Yaptenco, R. C., M. R. Harold and A. E. Wylie.

Pallet Manufacturing costs: A case study. 1968 Mich. Agr. Exp. Sta. Quart. Bul. 50: 365-383.

GRADES AND STANDARDS OF FOREST PRODUCTS

Research Problem Area 512.

Grades and standards and their relationship to profit is the subject of research in the states. Grades that are uniformly different will assist in the development of standards to adequately describe a product in terms of its expected performance.

University of MISSOURI 535

Growth-quality evaluation of the wood of oak, pine, and redcedar. E. A. McGinnis, Jr.

Moisture content (standing trees), percent extractables, specific gravity, and other wood-quality parameters have been determined for 12 native hardwoods. Data are being evaluated. Electron microscopic examination of faces of black walnut verifies light micro-

scopic findings, i.e., for ring shake, separation occurs within the middle lamella zone in the majority of studied cases.

The frequency and selected anatomical features of included sapwood in Eastern redcedar was estimated from studies of nine trees. Findings reveal that abnormal tissue structure (result of "wounding" or frost damage) is not necessary for separation of included sapwood—heartwood tissue at the junctions of these zones on the bark side of the tree. Several separations were found without formation of abnormal cell structure. Cross-sectional profiles ("P" indicates pith for reference purposes) and radial profiles of included sapwood zones in redcedar are shown in fig. 36.

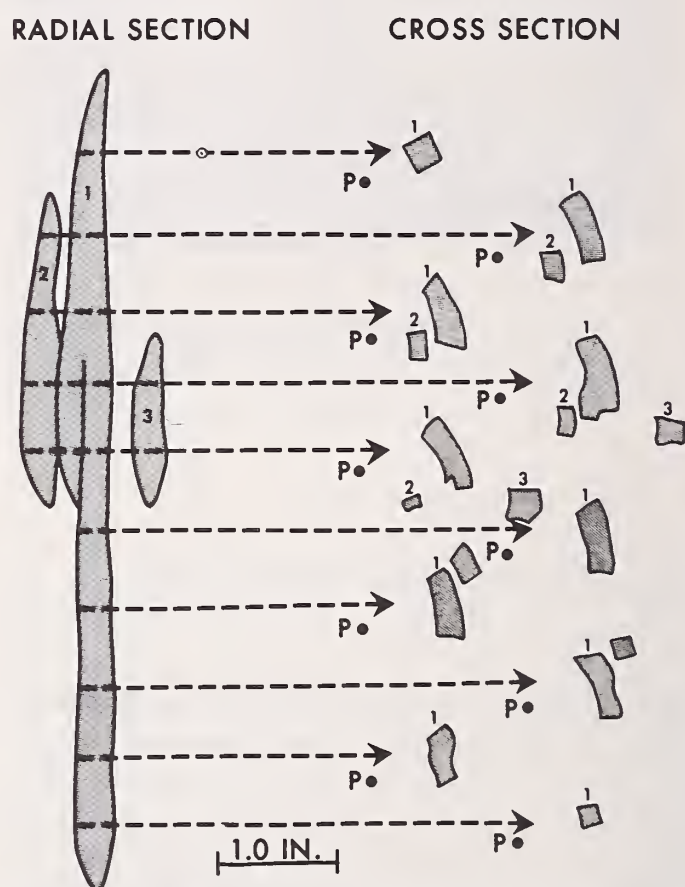


Figure 36. Profiles of included sapwood zones in redcedar. University of Missouri 535.

ADDITIONAL PROJECTS

Northern ARIZONA University 2

Wood quality and growth of Southwestern ponderosa pine. G. Voorhies

University of VERMONT 1

Quality spruce and balsam fir for Christmas-tree culture. M. L. McCormack, Jr.

University of VERMONT 8

Soil-growth-wood quality of birch. P. R. Hannah

University of WASHINGTON 4

Influence of environment on the quality of wood of Douglas-fir. J. S. Bethel

WASHINGTON State University 1929

Factors affecting the vibrational parameters of structural lumber. R. F. Pellerin

University of WISCONSIN 1518

Avoiding checks in wood and wood products. H. J. Kubler

PUBLICATIONS

Kinerson, R. S., Jr.

1968 *Effects of some environmental factors on establishment and development of balsam fir Christmas tree plantations.* Misc. Publ. 50, Vermont Agricultural Experiment Station. 21 pp.

McGinnes, E. A., Jr.

1968 *Extent of Shake in Black Walnut.* For. Prod. Jour. 18(5): 80-82.

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SUPPLY, DEMAND, AND PRICE ANALYSIS OF FOREST PRODUCTS

Research Problem Area 513.

Research data are here applied to development of improved forecasts of supply, demand, and prices of forest products as a necessary requisite to efficient and orderly planning for production and marketing.

University of GEORGIA 21

Prediction of growth and yield of loblolly and slash pine plantations. J. L. Clutter

A publication was produced summarizing the results of research on slash pine plantations. The techniques

presented permit the prediction of joint pulpwood-sawtimber-gum yields for stands of varying age, site, and density. Data analysis for an extensive loblolly pine plantation study was completed. This analysis resulted in the development of new site index curves, volume tables and per acre cubic volume, green weight, and dry weight yield tables. Publications presenting these results are in preparation.

Two subprojects concerning thinning in slash pine plantations and yields of rough-woods slash pine plantations were completed. Field data were collected in slash pine plantations to a) construct site index curves from stem analysis measurements and b) investigate the spatial distribution pattern of tree diameters in areas such as that shown in fig. 37.

MISSISSIPPI State University 1124

Availability, consumption, retail marketing practices, and species preferences for softwood lumber in Mississippi. F. W. Taylor and W. S. Thompson

Lumber and other wood products account for 63 percent of the total sales of Mississippi retail building supply dealers. Southern pine, which is handled by nearly all retail establishments, accounts for 66 percent of total lumber sales and is the major species used for framing, sheathing, and sub-flooring. Imported species are used mostly for studs and exposed areas to be painted. The typical retail dealer is located in a town of 8,000 population, has been in business for 11 years, employs between 8 and 12 people, and has gross sales of \$300,000 annually. Nonwood items (paint, tools, roofing, etc.) comprise 37% of his total sales. The remaining 63 percent are divided among lumber 31%, plywood 13%, and manufactured wood products 19%.

Homeowners and building contractors are the principal customers of retail dealers, accounting for 51 and 42 percent of total sales, respectively. Builders, who are the most influential group in determining the amount and species of wood used in construction, make most of their lumber purchases from wholesalers and producers. Although wood is the primary material used in house construction in Mississippi, it has been replaced by competing materials for certain uses. Only 7 percent of the houses constructed in the state during the past five years contained wood as the primary siding material; 80 percent of these houses were constructed on a concrete slab foundation, and



Figure 37. Slash pine plantation in the Upper Coastal Plain of Georgia. University of Georgia 21.

70 percent were equipped with metal window units. This project was terminated in July, 1968.

University of WISCONSIN 1364

Technological change in forest industries.

W. R. Bentley

Three interesting developments have occurred this past year. First, investigations regarding the nature of technological change have identified three sources of increased value productivity in the forest industries: 1. Response to changes in the relative prices of inputs (esp. labor, equipment, timber, and energy) and product outputs. 2. Shifts in present input combinations to attain greater technical efficiency. 3. Initiation of essentially new technology in processing and/or products.

Second, the primary causal factor is hypothesized to be managerial quality. Efforts are now being made to design methods for testing this hypothesis and providing measures of technological change (productivity increase) associated with each of the sources listed above.

Third, specific empirical research is focusing on pollution abatement by the pulp and paper industry. It is hypothesized that technological change alone has been the major cause of reduced pollution loadings by pulp and paper mills. This problem has been formulated in terms of positive and negative increments to present net worth associated with reductions in 5-day BOD and suspended solids. A technological matrix has been formulated for each major pulping and paper-making process. Technical stages in each subprocess reflect sequentially lower loadings. A

cost matrix by plant size is now being constructed to predict loadings associated with economically optimal plants and the cost of decreasing loadings still further. Older plants with mixed levels of technology also can be simulated. This work is being conducted in cooperation with the Wisconsin Water Resource Center and industry in the Wisconsin River Valley.

ADDITIONAL PROJECTS

University of ALASKA 270-7501

An analysis of the opportunities for integrated forest utilization in rainbelt area of Alaska. M. R. Massie

University of CALIFORNIA - Berkeley 2350

Methods of estimating long-range timber supply.
H. J. Vaux

Southern ILLINOIS University 67-R-1

Economic allocation resources for forestry.
R. I. Beazley

NORTH CAROLINA State University 4003

Foundations of American forest policy. J. O. Lammi

NORTH CAROLINA State University 4007

Systems analysis in the wood processing industries.
D. H. J. Steensen

PENNSYLVANIA State University 1625

Systems analysis for forest products industries.
P. C. Kersavage

VIRGINIA Polytechnic Institute 350011

An economic model for southern industrial forest regulation. E. F. Thompson

University of WASHINGTON 19

Structural change in the forest products industries of the Pacific Northwest. T. Waggener

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Bailey, R. L.

Cubic-foot volume tables for loblolly pine plantations in the Georgia Piedmont. Unpublished Thesis. University of Georgia.

Bennett, F. A. and J. L. Clutter.

Multiple-product yield estimates for unthinned slash pine plantations. Southeast For. Exp. Sta., U.S. Forest Service Res. Pap. SE-35.

Bentley, W. R.

Public timber sale policy in galbralthian reality. Wisconsin For. Res. Note No. 140. 7 pp.

Bentley, W. R. and L. L. Streeby.

Projected quality indexes for estimating hardwood log values. Wisconsin For. Res. Note. No. 142. 6 pp.

Burkhart, H. E.

Green and dry weight yields for loblolly pine plantations in the Georgia Piedmont. Unpublished Ph.D. dissertation, University of Georgia.

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Streeby, L. L. and W. R. Bentley.

QUINDEX-A program to estimate and project quality indexes for log grades. Wisconsin For. Res. Note No. 137. 13 pp.

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The theory of decision under uncertainty and possible applications in forest management. Forest Science 14 (2): 156-163.

Forest Products Utilization Research

Program Element 697

The objective of forest products utilization research is to provide a sound scientific and technical basis for using the national timber resource fully, efficiently, and economically. A major problem facing the industry is the continued decline in quality in available timber and the necessity for producing wood products from tree species not previously considered utilizable and which occupy large portions of forest land.

NEW AND IMPROVED FOREST PRODUCTS

Research Problem Area 401.

Basic and applied research in wood process and product development, wood fiber and chemical products, and in engineering of wood structures are research topics in this comprehensive area. Particular emphasis is devoted to wood property analysis and to the modification of these unique properties to create new dimensions for wood in the market place.

Southern ILLINOIS University 65-R-9

Moisture content gradients by vibrational techniques.

A. A. Moslemi

Degrading caused by improper drying of wood is currently widespread in the lumber industry. A major part of this is due to severe moisture gradients being present during the drying period. An early and effective detection of such gradients would enable the kiln operator to employ steaming and slow re-drying to reduce the effect of these damaging gradients. Our study was intended as a first step in developing a non-destructive gradient detection technique. Dr. Moslemi is shown at work in fig. 38. In the study, the vibrational characteristics of wood were employed and its usefulness in gradient detection was determined. The results indicate the vibrational properties have some value. Further research with conventional-sized lumber is necessary before any practical applications could be conceived. This project was terminated in 1968.

IOWA State University 1663

Fluid behavior in wood after processing.

J. D. Wellons III

The properties of wood-plastic composites vary with the amount of cell wall and cell lumen bulking.



Figure 38. Project leader examining one of the research specimens. Southern Illinois University 65-R-9.

Plastic located in the cell wall increases dimensional stability; in the cell lumen it increases compression strength and abrasion resistance. An engineered combination of both wall and lumen treatment would have great market value. This research aims to quantify changes in the above properties as a function of the location and amount of plastic in wood-plastic composites.

This year we evaluated one method for increasing the amount of plastic impregnated in the cell wall of silver maple. Kiln dried wood is almost inaccessible to plastic precursors. But the water in green wood can be replaced by less polar, more volatile organic solvents. Then when the wood is dried it shrinks less and becomes an aerogel more accessible to plastic precursors. We eliminated as much as 60% of drying shrinkage with this technique. Styrene and acrylonitrile vapor were impregnated in the cell wall of wood aerogels. They sorbed much more vapor than kiln dried wood samples, but sufficient vapor to cause

significant changes in the properties, was sorbed only at very high relative vapor pressures. Fig. 39 shows some measurements being done. During the coming year we will determine the maximum amount and rate that plastic precursor can be put in the cell wall of wood aerogels. We will also begin preparing wood plastic-composites with the maple aerogels.

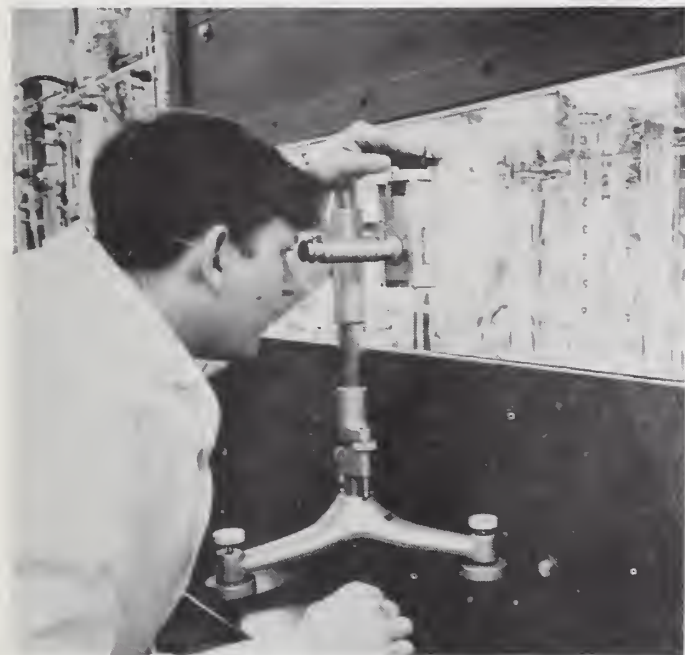


Figure 39. Sorption phenomena require precise observation and measurement as demonstrated by an assistant. Iowa State University 1663.

University of KENTUCKY 1028

Wood fiber mechanics.

R. Mark

A series of parametric relationships for fiber elastic constants have been generated by our computer program. These relate the moduli of elasticity of the wall of the fiber in axial and circumferential directions to the properties of the supermolecular constituents of each wall layer, and the geometrical considerations that result from the actual or theoretical filament winding angles of the cellulosic microfibrillar reinforcement in each layer, layer thicknesses, etc. See fig. 40. Similar curves have been generated for shear moduli of rigidity in the plane of the fiber wall. Correlative anatomical studies using polarization microscopy have been undertaken and are continuing, in order to provide real values for filament winding angles that may be used in connection with the above-mentioned analytical program. Further refinements in that program are being made.

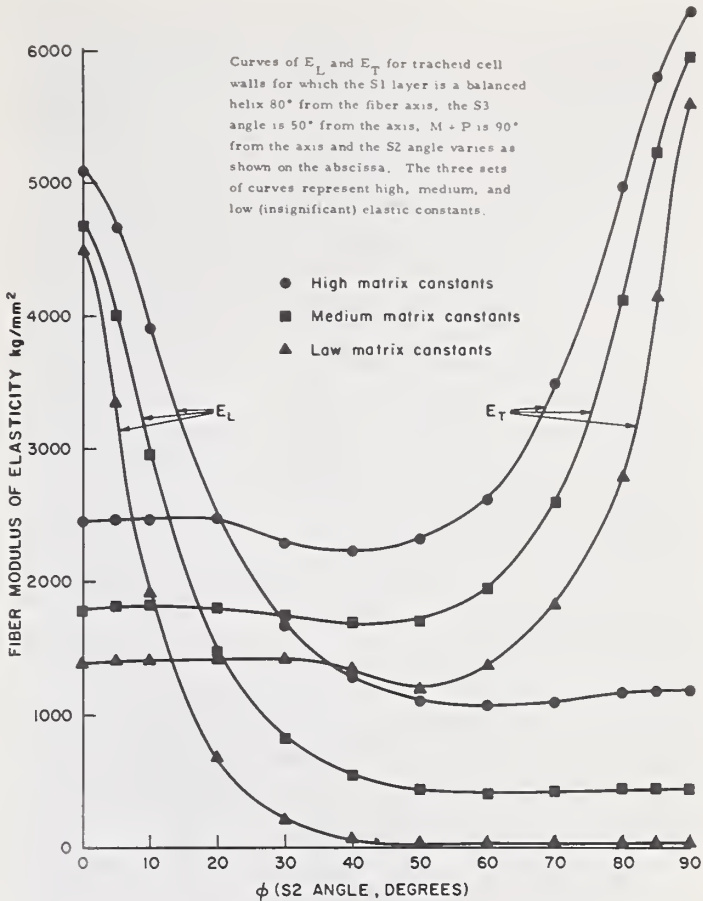


Figure 40. Parametric relationships for fiber elastic constants. University of Kentucky 1028.

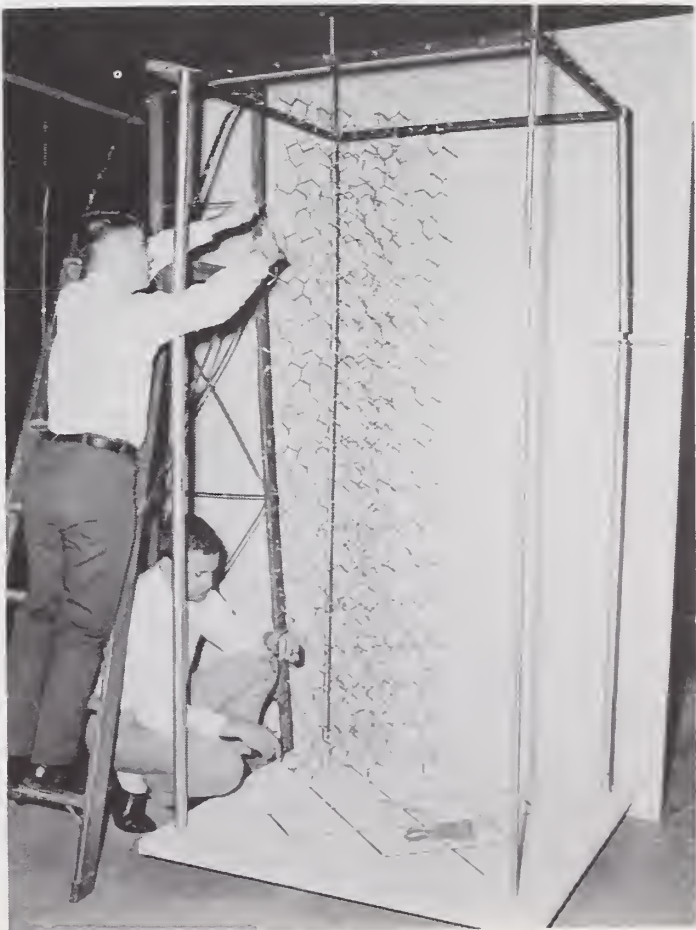


Figure 41. Large model of crystalline cellulose 1 being assembled. University of Kentucky 1028.

Aspects of biosynthesis of wood cellulose in the growing tree are being investigated with construction of a very large model of a 36-chain elementary fibril as shown in fig. 41. Biochemical studies to complement this work are being planned.

University of NEW HAMPSHIRE 3

Stress-strain in kiln-dried hardwoods.

J. L. Hill

Continued evaluation of shrinkage strain distribution in drying red oak lumber by the photoelastic method of strain analysis has revealed its value for this purpose. Previously, it has been reported that boundary strains determined by this method are comparable to expected shrinkage values. By using the oblique incidence technique on photoelastic coatings, the magnitude of principal strains at various points inside the free boundaries or edges can be calculated. Principal strain directions inside the board edges coincide with radial and tangential shrinkage directions (fig. 42). Calculated strain values compared at a



Figure 42. Photoelastic endcoating viewed with polarized light showing shrinkage strain distribution at an intermediate stage of drying. University of New Hampshire 3.

point with published unrestrained shrinkage data indicates amount of compression or tension set developing at that point. Differences in respective radial and tangential strain at different points having the same moisture content indicate that varying degrees of restraint have occurred and pinpoint critical strain regions. Comparative information on

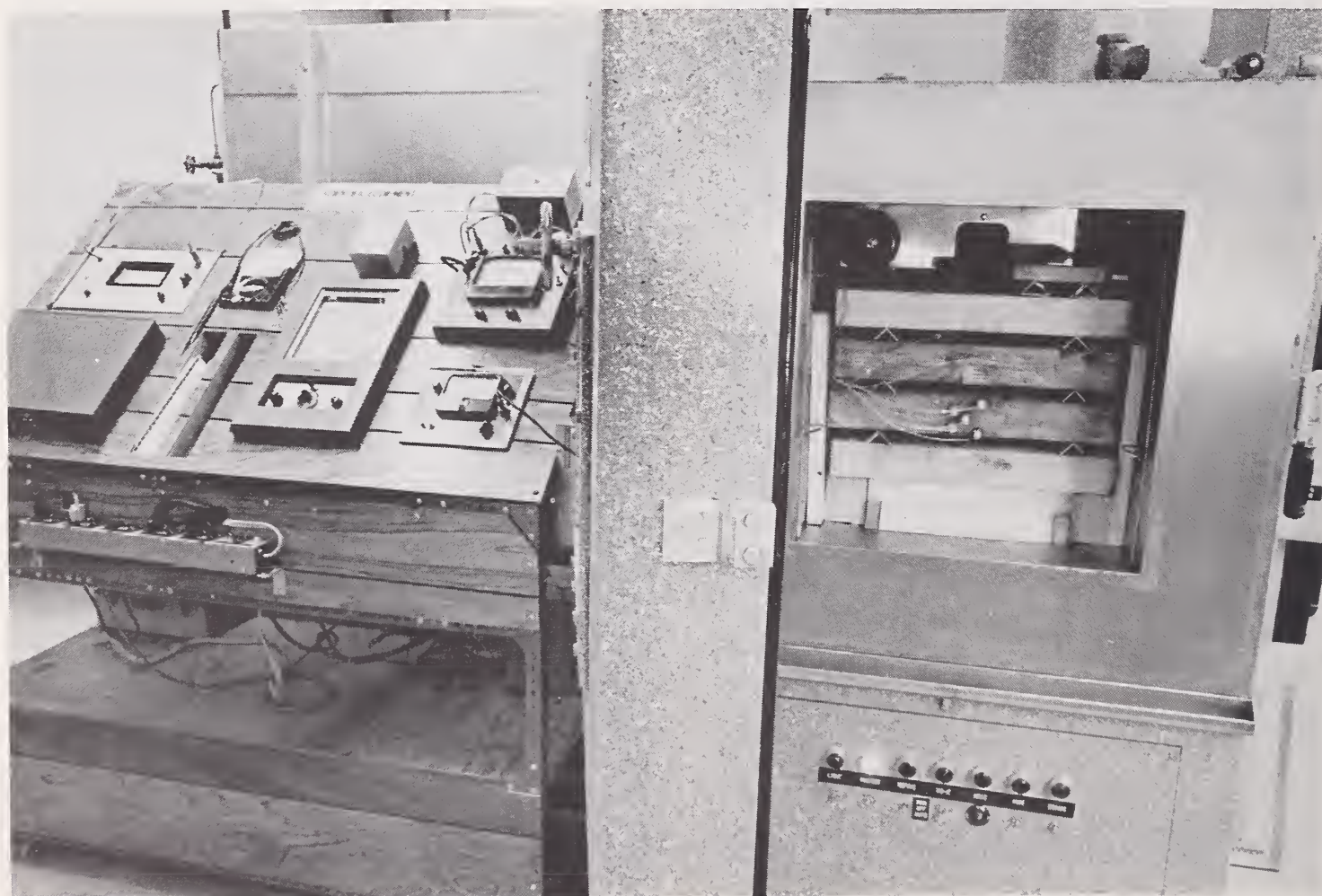


Figure 43. Instrument console (left) and open environmental chamber (right) with probes inserted in end-sealed board. University of New Hampshire 3.

the amount of restraint occurring along the principal axes of wood during drying is useful and has not been readily available previously. In order to provide internal temperature and moisture content data needed for the photoelastic and the Moire' strain analysis, a remote temperature and moisture sensing probe has been perfected. The combination of remote internal moisture, wet and dry bulb temperature sensing (fig. 43), and strain analysis techniques may permit the development of fully automatic kiln drying procedures.

OREGON State University F647

Gamma radiation induced reactions of flavonoid compounds from bark. H. Aft

Quercetin, a flavonoid compound extracted from bark was exposed to cobalt-60 gamma irradiation as an initial part of the study. Results of the reactions upon exposure of quercetin in absolute alcohol under nitrogen have been analyzed. Dimeric, trimeric, and tetrameric flavonoid compounds were isolated as the major products of the reaction. Studies show the flavonoid nucleus has remained intact in these compounds. The dimeric products appear to have structures closely related to a dimeric flavonoid product isolated as an intermediate in the conversion of dihydroquercetin to cyanidin derivatives in a companion study also underway at the Laboratory. Determination of the dimeric flavonoid structure is important to both studies, since both compounds appear to be novel structures with potential importance in food processing.

One problem in these studies is the stereo configuration (three dimensional form) of dimeric products. A number of dimeric flavonoid compounds are described in the literature but the absolute configuration of most of these compounds has not been determined. A series of dimeric flavonoid compounds has been synthesized as an integral part of the structural determination of compounds obtained from radiolysis of quercetin. During synthesis, it was observed that the configuration of the dimers as well as simple molecular substitution patterns (principally hydroxyl groups) was directly related to certain "energy reactions" of these compounds, such as thermochromism, piezochromism, and photochromism (fig. 44). The energy reactions are not completely understood and basic information regarding these properties and molecular structure is of



Figure 44. Separation of reaction products using column chromatography monitored by fluorescence under ultraviolet light. Oregon State University F647.

great interest. There is the additional possibility that development of chemical products exhibiting similar properties could find specialty use in reproduction papers requiring no carbon, light sensitive products, and computer memory systems.

OREGON State University F812

Electrical properties of wood below radio frequency.

R. T. Lin

Dielectric properties of wood subjected to frequencies from 20 cycles to 300 kilocycles per second were investigated using an electronic capacitance measurement assembly. Effect of moisture content and temperature on dielectric properties of Douglas-fir, western hemlock, and red alder at low audio frequencies was much greater than at radio frequencies. Indications are that dielectric properties measured at low frequency may be a better method for determining the effect of various characteristics of wood, such as moisture content or density. The theory of

dielectric mixture was adapted to explain the effect of moisture content on the dielectric constant of wood. A hypothetical coefficient accounting for the dielectric interaction between water molecules and wood substance may be thermodynamic. This is based on the analysis and comparison of the hypothetical coefficient with the differential heat of wetting of wood.

The effect of heat treatment on the dielectric properties of wood was also investigated. Change in dielectric properties was very rapid up to 40 hours exposure at 170°C and gradually tapered off beyond this point. Change in color of wood because of heat treatment was measured with a surface reflectometer. Percent light reflectance from the surface decreased with increase in thermal degradation.

Effect of tensile stress (parallel-to-grain) on dielectric properties was studied for Douglas-fir. Changes in dielectric properties could not be measured quantitatively with present instrumentation (fig. 45). However, it was shown qualitatively that there is strong interaction between the dielectric properties of wood and the mechanical force field such as tension stress or compression stress. This may prove important in developing a new concept in non-destructive testing of wood.

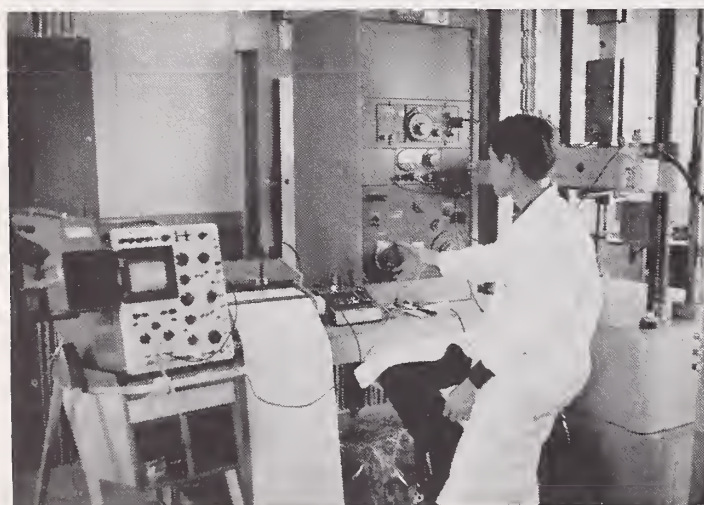


Figure 45. Measurement of change in dielectric properties of Douglas fir when stress in tension-parallel-to-grain was applied to the specimen. Oregon State University F812.

PENNSYLVANIA State University 1489

Rheology of wood cellulose in situ. W. K. Murphey

One hundred, micron-thick, oven-dry, Douglas-fir samples were placed in an N₂ environment on an

X-ray diffractometer (fig. 46). Diffraction patterns of cellulose (10° - 2 to 28° - 2) were taken as: 1. Temperature levels of 20°C, 60°C, and 100°C were imposed on the specimens loaded incrementally to 10, 20, 30, 40 or 50 percent of ultimate tensile load. 2. Loads were maintained at one of the levels and temperatures varied. Changes in the 002 peak were read while treatments 1 or 2 were imposed.

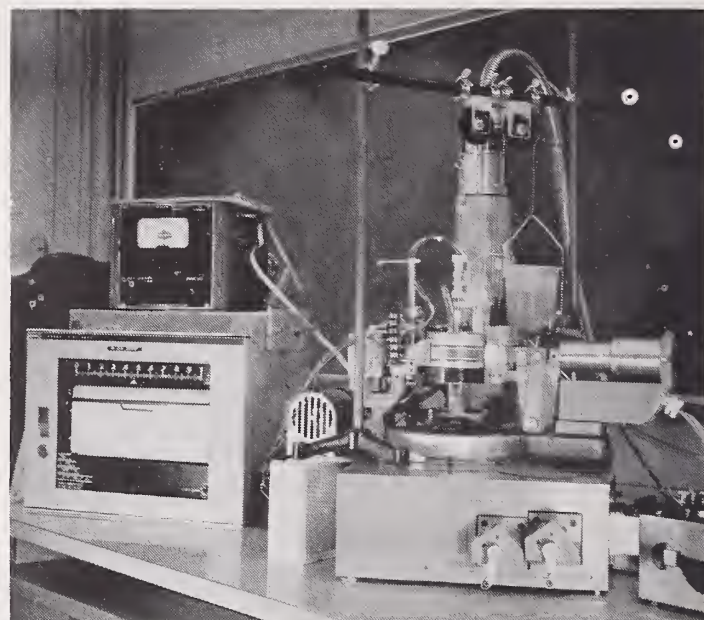


Figure 46. Analytical set-up for controlled environment diffractometry. Pennsylvania State University 1489.

Relationships between tensile load, temperature level, strain, and index of order of cellulose were investigated. Index of order varied inversely with temperature and directly with load. Load changes at a given temperature directly affect change in amount of strain.

It is assumed that an increase in alignment of cellulose chains occurs over an extended period of time due to imposed stress.

VIRGINIA Polytechnic Institute 350021

Accelerated seasoning of large-dimension wood products. R. E. Martin

In one aspect of this study, diffusion equation solutions have been used to predict drying diffusion coefficients in wood, and these, in turn, to predict drying rates. One form of diffusion equation solution has allowed the prediction of a concentration-dependent drying diffusion coefficient. A technique is in development for measurement of internal wood

temperature in dielectric fields. Another aspect of the study is concerned with the radial variation of equilibrium moisture contents of wood and the effects of stress on the moisture content. The interdependency of these factors is also being considered. A third aspect of the study is concerned with the effect of wood ultrastructure on wood seasoning. The effect of method of seasoning on the pits or interconnecting passageways between wood cells is being considered. As shown also by other investigators, the torus or central portion of a pit membrane in wood dried from water will often be drawn against the aperture or opening into a cell lumen by the surface tension forces of water. When this happens, one would expect a decreased permeability to the penetration of fluids, such as preservatives. On the other hand, by exchanging the water with miscible

liquids with smaller surface tension forces, the torus may be left suspended and allow freer passage of liquids (fig. 47). Quantitative measurements of liquid permeability as well as economical means of keeping wood more permeable are being undertaken.

University of WASHINGTON 13

Mathematics of fiber assemblages.

G. G. Allan

Analysis of the fundamental geometry of fibers in a randomly deposited assembly in terms of their basically triangular structural components has been continued. The previous work on hollow fibers has been expanded to include the buckling phenomenon which allows a stiff fiber to collapse to a rectangular member with a high intrinsic flexibility. An analysis

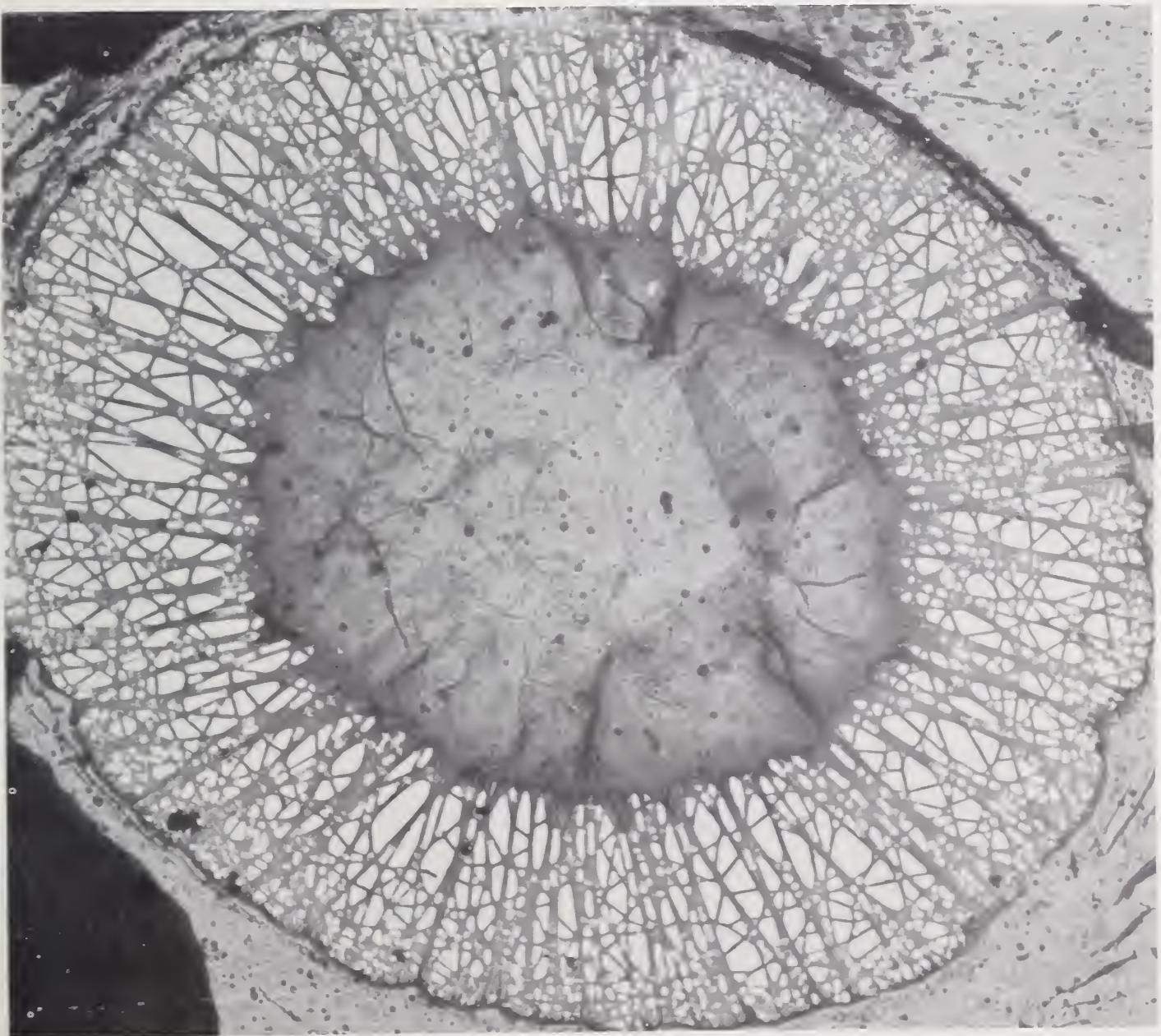


Figure 47. Electron micrograph showing openings in pit membrane through which liquids can move (X 5,000). Virginia Polytechnic Institute 350021.

of the effect of two-dimensional crimp on the flexibilization of the triangular elements in a randomly deposited fiber mass has also been made and extended to the three-dimensional case. The latter has been experimentally verified by the use of helical spring models. A general photochemical method for the precise location of polymer within a fibrous mass has been developed. The procedure consists of impregnating the fiber mass with an emulsion-stabilized polymer latex. The emulsifier employed can be deactivated by a radiation-triggered reaction, and this deactivation causes a selective coagulation of the polymer latex to give an image corresponding to the pattern of incident light. As a test of the method, polyvinyl acetate emulsified with polyvinyl alcohol has been deactivated with various dichromates, and a reaction mechanism proposed. The rate of binder deposition was found to be enhanced by increased light intensity and exposure time and by factors which reduce the stability of the impregnating latex. All of this information should be of practical value in the design of nonwovens for specific applications.

University of WASHINGTON 15

Solution of problems in orthotropic and anisotropic elasticity. B. A. Jayne

During the past year, a solution for the stress field in the vicinity of a rigid square core in an anisotropic body was obtained. This solution completes that phase of the research concerned with plane and three-dimensional boundary value problems. In the future, emphasis will be placed on the micro-mechanics of fibrous orthotropic systems. Particular emphasis will be placed on the calculation of stresses in the vicinity of fibers embedded in a continuum matrix.

ADDITIONAL PROJECTS

University of CALIFORNIA - Berkeley 2495

Chemistry and utilization of bark. A. B. Anderson

COLORADO State University 314

Particle board from Colorado species.

H. E. Troxell and D. L. Crews

University of IDAHO 7

Unit fiber stress in rings of Douglas-fir.

A. D. Hofstrand

University of IDAHO 8

Grain angle and strength of Douglas-fir. J. P. Howe

University of ILLINOIS 334

Penta-treatment and strength of Douglas-fir.

C. S. Walters

University of KENTUCKY 1029

Composite pole laminates.

R. Mark

LOUISIANA State University 1440

Liquid and gas permeability of wood. E. T. Choong

LOUISIANA Polytechnic Institute 3

Bark residues as soil conditioner.

J. Wright and O. L. Fitzgerald

University of MAINE 5003

Density and seasoning of plantation-grown red pine.

G. Baker and N. P. Kutscha

University of MASSACHUSETTS 3

Rheology of wood restrained from swelling.

R. B. Hoadley

University of MASSACHUSETTS 4

Wood properties of red pine.

H. B. Gatslick

University of MINNESOTA 19-55

Flexural creep and stress-rupture in aspen hardboards.

J. G. Haygreen

University of MINNESOTA 19-56

Characteristics of freezing for the accelerated drying of commercially important species.

R. W. Erickson

University of MINNESOTA 19-60

The properties, production, and trade acceptance of aspen studs.

R. D. Thompson

- MISSISSIPPI State University 3621
Variations in shrinkage of second-growth Southern yellow pine. J. Yao
- MISSISSIPPI State University 3622
Preservation of Southern pine poles and piling. W. S. Thompson
- MISSISSIPPI State University 3623
Wood properties of delta hardwoods. W. S. Thompson
- MISSISSIPPI State University 3624
Efficiency in lumber manufacture. W. S. Thompson and W. R. Fox
- MISSISSIPPI State University 3625
Development of wood adhesives. H. R. Rogers
- MISSISSIPPI State University 3626
Laminated hardwood lumber for furniture manufacture. J. Yao
- University of MONTANA 210-401
Variability of Western Larch wood. J. P. Krier and J. L. Faurot
- NEW MEXICO State University 6
Economic feasibility of a particleboard industry in New Mexico. J. R. Gray
- NORTH CAROLINA State University 4002
Wood property variation in tupelo gum. R. L. McElwee
- NORTH CAROLINA State University 4005
Wood fiber properties and paper quality. E. L. Ellwood, A. C. Barefoot and R. G. Hitchings
- NORTH CAROLINA State University 4006
Gas phase treatment of wood. A. J. Stamm
- NORTH CAROLINA State University 4008
Sizing of paper and paperboard. C. G. Landes
- NORTH CAROLINA State University 4009
Mathematical description of the mechanical behavior of wood. J. Hsu and R. Gilmore
- NORTH CAROLINA State University 4019
Preparative Fractionation of cellulose by Gel permeation chromatography. W. Brown
- OKLAHOMA State University 1246
Wood properties of shortleaf pine. C. E. Posey
- OREGON State University F-763
Anatomical and chemical characteristics of permeable and refractory Western hemlock. R. T. Lin
- OREGON State University F-825
Effect of environmental and genetic factors on pulping of Oregon woods. W. J. Bublitz and M. D. McKimmy
- PENNSYLVANIA State University 1492
Kerfless cutting with a knife. W. K. Murphey
- PENNSYLVANIA State University 1781
Knife variables associated with slicing wood. W. K. Murphey
- University of TENNESSEE 9
Hardwood characteristics. H. A. Core
- UTAH State University 767
Efficiency of lumber manufacture in Utah. A. B. Furniss
- University of WASHINGTON 10
Wood anatomy and processing of veneer. L. Leney
- WASHINGTON State University 1772
Piezoelectric effect in wood. W. L. Galligan

WASHINGTON State University 1775

Moisture relationships of wood at high temperature.
M. D. Strickler

WASHINGTON State University 1942

Influence of wood structure on shear strength of Douglas-fir.
A. F. Noskowiak

WEST VIRGINIA University 2

Growth rate and specific gravity of hardwoods.
J. R. Hamilton

WEST VIRGINIA University 3

Utilization of sprout black cherry. C. B. Koch

WEST VIRGINIA University 4

Alternate methods of lumber handling. D. E. White

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Chapter 5

FOREST RECREATION, WILDLIFE, AND NATURAL BEAUTY

Outdoor Recreation Research

Program Element 698

The demand for outdoor recreation facilities has far exceeded projections, and a vast research effort is necessary to furnish management tools for public and private forest lands to meet the recreation demand in coordination with other resource uses. Information is also needed to develop income producing recreation areas on public and privately owned woodlands.

FORESTLAND RECREATION

Research Problem Area 902.

Forestland recreation research in the states covers recreation demand, appraisal of recreation resources, and development of data for management. Increasing attention is directed to the human element and to an analysis of their woodlands recreation requirements with respect to the resource available—a particularly urgent problem within convenient driving distance of large urban centers.

University of ARIZONA 620

Forest recreation demand analysis.

D. A. King

The study of family campers (fig. 48) in the Graham Mountains Recreation Area has provided estimates of total numbers of camping groups, length of stays, and socioeconomic characteristics of the campers. The planned comparisons of socioeconomic variables, motives for camping, and use rates among campgrounds is in progress. Since a stratified cluster sample with unequal cluster sizes was used, the analysis is complicated by the necessity for weighting the data. During the coming year, work will begin on the development of a use prediction model for the area.

The analysis of the recreation survey of Tucson households has been completed. An M.S. thesis, entitled "The Demand for Land-Based Outdoor Recreation in the Tucson Area," based on this survey will be completed by February 1, 1969. Maximum willingness-to-pay curves were developed for three recreation areas in this study. Further analysis to be



Figure 48. Developed mountain recreation site. University of Arizona 620.

undertaken in the coming year will include an analysis of the responses to the question of how outdoor recreation should be financed. A study of the Tucson Jeep Club and the Tucson Sandbuggy Association is nearing completion. The use patterns and socioeconomic characteristics of the members of the two clubs are being compared.

CALIFORNIA - Humboldt State College 7

Ecology for recreation in second-growth redwoods.

W. F. Murison

A detailed survey and inventory was completed of the physiographic features of the Camp Bauer area including an 85 acre, second-growth redwood stand in Humboldt County. The resources of the area, basically the second-growth redwood stand and associated components, provide definite recreation potential from an educational-recreation aspect. Topographic features and vegetation of the area are well suited to the development of educational nature trails that incorporate interesting ecological factors inherent in the stands, as well as on-site logging artifacts. Management objectives for the area have been clarified and policy directives for the future have been enumerated. Major obstacles to recreation development have been recognized and include: access, water supply, and sanitation. At times, climate is a limiting factor. Resources of this area possess sufficient diversity and offer adequate appeal with variegated outdoor activities to allow for the staged development of recreational activities in the stand well into the future. This project was terminated.

CALIFORNIA - Humboldt State College 8

Snow hydrology study to evaluate winter recreation potential of Horse Mountain ski area.

D. T. Jager

During the winter of 1966-67, a continuous snow cover existed on Horse Mountain from November 30th until May 21st, with maximum snow depths occurring in April. During this period, snow depth was adequate to permit favorable skiing from February 1st through May 15th. The area served a total of 2,200 skiers and 700 snowplayers during the 1966-1967 season. Snow quality was in excess of 90 percent from February 15th until April 30th, indicating inherent snow stability during this period. Mean snow depth and water content was respectively

70.3 and 24.3 inches at the weather station (elev. 4,820 ft.) in April. Statistical analysis of snow data from the study basins indicated no significant differences in snowfall accumulation and retention between basins. However, significant differences in snow retention existed on ski slopes relevant to aspect and slope steepness. For example, a northwest-facing ski slope with a slope steepness of 45 percent retained 40 percent more snow on May 14th than did another slope with the same aspect and a steepness of 20 percent.

Basic snow data obtained in this study provided useful information on snow water storage in Humboldt County; information which has been essentially unavailable for the County to date. This project has been terminated.

LOUISIANA State University 1177

The role of large private forest owners in outdoor recreation in Louisiana.

R. W. McDermid

Owners of forested areas larger than 5,000 acres permit the general public to use 77.2 percent of this land for recreation. Such use is generally for hunting, fishing, or camping. Fig. 49 shows such an area open to the public.

Industrial owners permit a larger proportion to be used than other owners. Most small owners do not want the public to use their land at all. Part of this reluctance may be caused by fear of legal liability, since Louisiana's limited liability law has not been tested in court.

Recreational leases are expected to increase. Two main reasons for this are: (a) the profit motive, (b) better control of the user by the landowner. Hunting leases are the most popular kind. With proper advertisement, collective action by the landowners in leasing large tracts to the state, free of charge, for game management and public hunting, could result in an improved public image, thus fewer conflicts, and would furnish the public with excellent shooting areas. If public use becomes incompatible with timber growing, as present owners suspect, some type of controlled use may become necessary, such as the charging of fees.



Figure 49. Picnic facilities on privately owned forest land managed for pulpwood production. Louisiana State University 1177.

LOUISIANA State University 1232

An evaluation of the effect of State forests and parks on public recreational use of private forests.

R. W. McDermid

Findings include the following for Fontainebleau State Park: (fig. 50)

1. Visitors to the park increased ten-fold (to 500,000) since 1955.
2. Out-of-state visitors to this park contributed \$641,000 to the area's economy in 1966.

Recommendations for Fontainebleau Park:

1. Repair beach area and provide up to 15 additional acres of swimming beach.

2. Locate portable chemical toilets throughout park in summer.
3. Provide better restroom maintenance in summer.
4. Erect highway signs at strategic locations giving directions to park.
5. Charge admission fee of 50 cents per car and reinvest in park improvements.

Recommendations for all State parks:

Regardless of camping equipment used, campers want flush toilets, all-night lighting, and campsite separation by screening underbrush. On new installations, a preliminary study should determine type of equipment used in order to gear expenditures to



Figure 50. Attractions at Louisiana's Fontainebleau State Park include the stately avenue of live oak (left) and remnants of a colonial period building (right). Louisiana State University 1232.

practical uses. *Do not* build tent pads, picnic or open-fire grills, or direct sewer drops for each unit. These involve unnecessary expenditures of funds.

University of NEVADA 672

Recreational uses and factors influencing their quality and quantity in isolated forest and rangelands.

P. T. Tueller and J. B. Woody

Final report includes: (1) description of flora, fauna, geology, land ownership, and resident uses; (2) count of recreation visits at selected periods for entire 2-1/2 million acre area; (3) vital statistics and attitude profiles of resource uses by residents and non-residents; (4) identification of 7 areas for recreation development; (5) average expenditures by visitors; (6) description of land abuses, including wholesale illegal mining of petrified wood, destruction of springs and meadows by overgrazing, and littering of campsites; and (7) management recommendations for future development or preservation. This project was terminated in August, 1968.

UTAH State University 739

Interagency cooperation for Flaming Gorge National Recreation Area.

R. A. Ogle

Most of the field work has been completed. Data have been collected at the local, regional and national levels. Preliminary findings indicate that administrative institutions operate in a manner that rewards interagency cooperation at the local level, but discourages cooperation at the regional and national

level. Some of the primary mechanisms which affect interagency cooperation appear to be: spatial distribution of institutional offices, enforced interagency social contact of personnel, and interagency competition for similar programs.

ADDITIONAL PROJECTS

Northern ARIZONA University 6

Management of the forest recreation resource in Arizona.

L. D. Love and A. J. Schultz

COLORADO State University 313

Inventory of forest recreation resources.

A. T. Wilcox

University of IDAHO 4

Methods for estimating recreational visits and use on unattended recreation sites.

H. R. Alden

Southern ILLINOIS University 66-R-26

A master plan for Devils Kirchen Lake.

D. R. McCurdy

Southern ILLINOIS University 67-R-23

Techniques for measuring recreation use of land.

D. R. McCurdy

IOWA State University 1580

Forest-recreation investment opportunities.

H. H. Webster and F. S. Hopkins

University of MARYLAND T-16

Forest recreation—The valves placed on trees for recreation environment. F. H. Forsyth

MICHIGAN State University 1029

The recreation capacity of a small lake and implications for planning and development. M. Chubb

MICHIGAN Technological University 2-3016

Recreational opportunities on industrial forests in the Keweenaw Bay area, Michigan. C. R. Crowther

University of MINNESOTA 19-43

Recreation land management and user satisfaction at several Minnesota park and forest areas. F. H. Kaufert

University of MINNESOTA 19-77

Ecological implications of the management of Itasca State Park to meet recreational objectives. H. L. Hansen

University of MONTANA 804

Recreation use of forest lands in Montana. S. S. Frissell

NEW YORK - Cornell University 903

Suburban forest ownership. L. S. Hamilton

PENNSYLVANIA State University 1494

Wildland recreational management. J. L. George, J. S. Lindzey, R. A. Bartoo and W. W. Ward

SOUTH DAKOTA State University 420

Establishment of tree plantings to enhance recreation potential of selected sites. E. Collins

University of TENNESSEE 5

Recreation resources of large private forest ownerships. K. F. Schell

UTAH State University 669

Predicting campground use. R. S. Whaley

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Recreational uses of isolated rangelands in
1968 *Northwestern Nevada*. M.S. Thesis. Univ. of
Nevada, Reno, Nevada. 147 pp.

Wildlife and Fish Research

Program Element 699

A large measure of forest resource value resides in vast populations of wildlife and fish and, like the land itself, these two valuable resources are subjected to increasing demands of sportsmen and recreationers. The crux of optimum game and fish management lies in the ability of the habitat to supply abundant food, cover, and water. The plant-animal and plant-fish ecologies of forested land are the subject of intense study to furnish management tools essential to habitat maintenance.

WILDLIFE AND FISH BIOLOGY AND HABITAT

Research Problem Area 904.

Forestry research in this problem area deals with habitat management and the relationships of the wildlife species to their environment in the face of a decreasing land base and increasing use by man. The benefits of this research are primarily recreation oriented but the large source of protein involved is an important secondary impact.

CALIFORNIA - Humboldt State College 5

Ecology of Roosevelt Elk in redwoods. G. B. Donart

Two cutover areas in the Coast Redwood timber type were surveyed to determine species composition, elk utilization and preferences for existing forage. Cutover areas of different ages were used to obtain a

trend for preference of old and new forage growth. Kirsch cutover, an area within Prairie Creek Redwoods State Park, is 16 years old and was not burned after logging. The Arcata Redwood Company study area (8 years old) was clearcut, and then slash burned and reseeded with sitka spruce (*Picea sitchensis*) and Douglas-fir (*Pseudotsuga menziesii*) in 1962-63. The older cutover was declining in elk use with age in comparison with use on the more recent cutover. The same preference for plants existed but the percent utilization of seedling trees on ARCO was much greater than on the Kirsch cutover due to availability and percent composition in the seedling class.

Burning affected elk use to the extent that dense fern cover was removed, thus reducing competition and permitting valuable grass and forb species to grow in open areas. A mixture of browse, forbs, and grasses appears to be more beneficial to elk production than more restricted diets of any one type of plant. This project has been terminated.

Habitat analyses of two Northeastern cottontails.

R. D. McDowell

A study area in northwestern Connecticut, representative of the northern hardwoods forest of the northeastern United States, was selected. Preliminary trapping results indicate that the population has altered from one that, ten years ago, consisted of 100% New England cottontails (*Sylvilagus transitionalis*) to one that now includes 20% eastern cottontails (*S. floridanus* ssp.). Differences between utilization of microhabitats during the fall and winter months were determined by trapping, tagging, and releasing resident animals (fig. 51). Investigations involving differences between utilization of microhabitats during the spring and summer months were inaugurated.



Figure 51. Rabbit marked and ready for release. University of Connecticut 376.

University of DELAWARE 715-E

Wildland ecology and urban impact.

R. Jones

Continued effort has been applied on both indicator and diversity indices approaches for evaluating urban impact on forest ecosystems in northern New Castle County. Woodthrush, because of a specific need for nest sites in low shrubs, tend to disappear with the development of parklands or housing and are replaced

by robins whose needs are not as exacting. Gray squirrel leaf nests were being used to evaluate population trends in urban forests. However, intensive studies of the nest construction and use appear to indicate that rather than number of squirrels, the presence of suitable sites determines the number of leaf nests. Diversity patterns of a newly created forest edge indicate that after four years new species can be found as far as 100 ft. from the edge. Species numbers along the edge increased by nearly 100 percent over the adjoining forest lands. Loss of trees along this edge was noted in those sites where minor changes in water drainage patterns were made. Forest land located close to major highways have lowered bird populations. An experiment was initiated to examine changes in the soil fauna under conditions of trampling and leaf removal. This experiment will indicate the effect of parkland management and use on the decomposed portion of the forest ecosystem.

University of FLORIDA 1032

Ecology of wildlife using sites mechanically prepared for pine planting.

S. L. Beckwith

Based on track counts during August there was no difference in the use by deer of cleared (fig. 52) and uncleared portions of the partially cleared plots, but deer appeared more numerous in the 75% cleared plots than in the plots with only 50% of the original vegetation replaced with pines. September counts showed a continuation of the poor deer habitat provided by complete clearing and planting pine (12.0 tracks per plot) as compared to 75% clearing (19.2 tracks) and 50% clearing (34.2 tracks). Uncleared plots had 27.2 tracks per plot. Rodent abundances, as indicated by trapping in June, were extremely low.

Vegetation studies in August showed a marked increase in *Aristida stricta* and *Quercus laevis* and herbs on uncleared areas compared to June 1967. The differences in month of the year may account for some of the increases in plants observed, but the absence of cattle during 1968 is probably of more significance, particularly in regard to the abundance of herbs. Grasses were 1.5X as abundant and herbs over 3X as abundant on the pine-planted areas than on the uncleared areas. Turkey oak acorn production was generally spotty and the 1968 production (7.5 acorns per tree) averaged less than 1/3 the production in 1967 (24.5 acorns per tree).

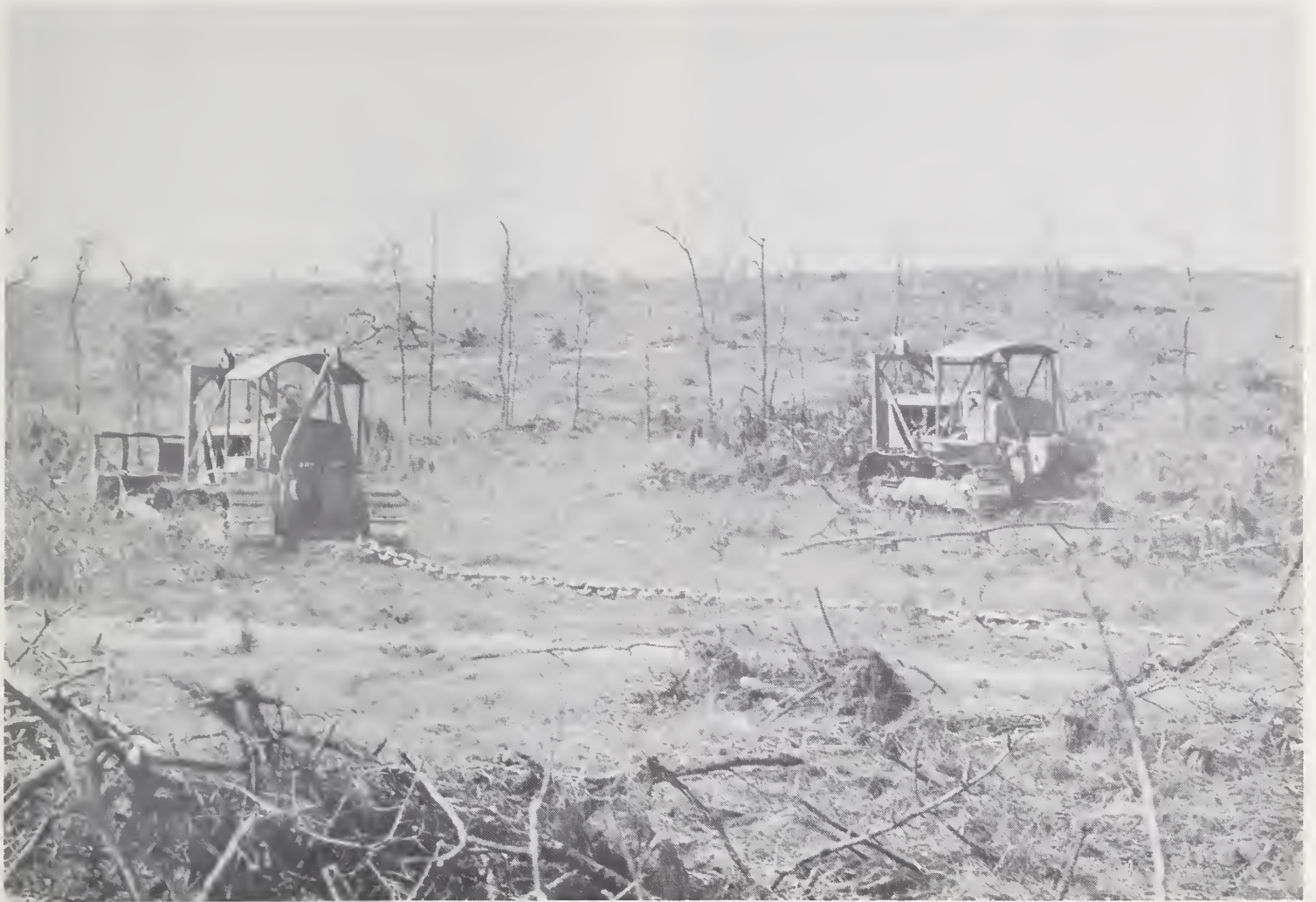


Figure 52. Clearing research sites for study plots. University of Florida 1032.

Two adjacent 40-acre pens were constructed for future studies on the use of mineral supplements by deer in natural habitats. Small pens for individual deer were also built to evaluate the use of selected browse species by deer.

LOUISIANA State University 1238

The influence of the Eastern woodrat in hardwood forests.

L. L. Glasgow

A study was made in Louisiana to determine effects of woodrats (*Neotoma floridana*) on squirrel (*Sciurus*) populations and on regeneration of oak (*Quercus*) trees in hardwood forests. There was no indication of competition between woodrats and squirrels for dens. Based on sample counts of dens, woodrat density ranged from 0.3 to 1.4 animals per acre. The highest density was in an area of high acorn production. Oak regeneration in this same habitat averaged 4,395 seedlings per acre.

Examination of food caches in dens indicated that woodrats eat fruits, stems, and leaves of numerous plant species and are not dependent upon acorns. In fact, feeding experiments with captive woodrats revealed they cannot maintain body weight on a diet consisting solely of acorns. Therefore, although woodrats are most abundant in habitat with high acorn yield, there is no evidence to indicate that they adversely affect squirrel populations or oak regenerations. Fig. 53 indicates some environmental difficulties that make such studies interesting.

University of MAINE 5005

Influence of deer upon vegetation. S. D. Schemnitz

Browsing activity by deer at Outer Heron were assessed by remeasuring permanent vegetation plots. A male and female deer, both radio-equipped, were released on April 10, 1968 to replace previous deer that had succumbed. Flight behavior patterns of deer



Figure 53. Hardwoods with dense understory consisting largely of palmetto. Woodrat numbers are high in this type of habitat. Louisiana State University 1238.

were recorded for 727 deer during June - September at Isle au Haut. There was very little difference in the mean flight distance, length of flight, and length of time before flight for the various sex and age groups. The flight responses of five color-marked deer were observed repeatedly and found to be similar to the entire sample. A trapping device not harmful to deer is shown in fig. 54.

An experimental seeding of Wagner flat pea (*Lathyrus sylvestris*) was established in cooperation with the Soil Conservation Service on an abandoned logging road on the University Forest. The degree of germination and height growth was variable but correlated with amount of lime and not fertilizer application. Feeding activity was noted by ruffed grouse. To date no deer feeding on pea has been observed.

University of TENNESSEE 3

Quail management on forest and associated lands in West Tennessee. R. W. Dimmick

This study is made to determine quail population trends on forested and agricultural lands in West Tennessee, and to learn the effect of various land management practices on quail and timber production. On the 2100-acre research area, quail density was 100 coveys (1440 quail) in December 1967, and 81 coveys (1073 quail) in March 1968. Bird dogs are used to locate and flush coveys as shown in fig. 55. This past year selected areas of nesting habitat, about 180 acres, were utilized for studies of quail nesting ecology. A total of 238 nests was located during the 1968 nesting season. Success of nests was determined



Figure 54. A single-gate nylon net clover trap used for capturing deer at Isle au Haut. University of Maine 5005.



Figure 55. Census worker prepares to flush and count quail located in dense brush by bird dog. University of Tennessee 3.

for 143 which contained eggs or egg fragments when found. Thirty-seven (26%) were successful, 100 (70%) were destroyed, and 6 (4%) were deserted. Mean size for 53 complete clutches was 11.5 eggs. Preferred habitat for nesting were "old fields" dominated by broomsedge (*Andropogon virginicus*); 77 percent of 238 nests were constructed at the base of clumps of broomsedge. Controlled burning designed to alter the stage of vegetative succession on pastures and idle lands had an apparent effect on the acceptability of these lands for nesting. For example, one field intensively used for nesting in 1967 (41 nests) was little used in 1968 (2 nests) after being controlled-burned. Similar fields which were not burned showed nesting densities not markedly changed from 1967 to 1968. Approximately 25 quail per month were collected to study food habits of this bird on the research area. Analysis of food in the crops is not complete.

ADDITIONAL PROJECTS

University of CONNECTICUT 340

Fetal sex ratio and productivity of white tailed deer.
R. D. McDowell

University of GEORGIA 11

Rabbit population response to small food patches in a Piedmont woodland environment. J. H. Jenkins

University of GEORGIA 12

Quail populations in relation to land succession.
J. H. Jenkins

University of GEORGIA 20

An evaluation of radioactive contaminants in wild animals of forest lands. J. H. Jenkins

Southern ILLINOIS University CW-7-67

*Dispersal of white-tailed deer (*Odocoileus virginianus*) from family units.* W. D. Klimstra

LOUISIANA State University 1356

Population studies of penned swamp rabbits in hardwood forests. F. W. Martin

University of MASSACHUSETTS 5

Food and shelter requirements of ruffed grouse in relation to energy regimes. R. B. Brander

MICHIGAN Technological University 2-3014

Ecology of a deciduous deeryard in Keweenaw County, Michigan. N. F. Sloan

NEW MEXICO State University 2

Effect of range and water on mule deer population. J. E. Wood

NEW YORK - Cornell University 902

Infrared detection of simulated animal damage on conifers. L. S. Hamilton and P. A. Murtha

NEW YORK - Cornell University 904

Evaluation of New York State's Fish and Wildlife Management act. L. S. Hamilton and J. W. Kelley

NEW YORK - Cornell University 907

Techniques for establishing vegetation for utilization by wildlife. J. W. Gaslick

NORTH CAROLINA State University 4020

Ecology studies of forest wildlife. F. S. Barkalow

University of RHODE ISLAND 953

Movements and activities of white tail deer in relation to extant and concurrent forest alteration. J. J. Kupa

University of TENNESSEE 6

Wood duck ecology in East Tennessee.

R. W. Dimmick

University of VERMONT 7

Habitat management and population dynamics of wood ducks.

R. W. Fuller

VIRGINIA Polytechnic Institute 350041

Effects of selected disturbance treatments in oak-hickory stands on deer browse.

B. S. McGinnis and H. S. Mosby

VIRGINIA Polytechnic Institute 350071

Effect of nutrient levels on reproductive function in white-tailed deer.

R. L. Kirkpatrick

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*
* * *

Table I. Forestry Disciplines Keyed to Research Problem Areas

RESEARCH PROBLEM AREAS		SOILS	PHYSIOLOGY	ECOLOGY	GENETICS	FIRE	PATHOLOGY	ENTOMOLOGY	SILVICULTURE	TIMBER MGT.	RECREATION	WILDLIFE	RANGE	WATERSHED	MULTIPLE-USE	ECON. & MKTG.	WOOD SCIENCE	PRODUCTS	
Soil Surv.	101	X																	101
Soil-Plant	102	X	X						X										102
Altern. Land Use	104														X	X			104
Water Conserv.	105													X					105
Watershed Tech.	107								X					X					107
Water Econ.	108															X			108
Weather	109			X															109
*Forest, Range Surv.	110									X									110
*Timber Mngt.	111		X	X					X	X						X			111
Range Mngt.	112												X			X			112
Remote Sensing	113			X		X	X		X	X	X		X	X	X				113
*Insects	201							X											201
*Diseases	202				X														202
*Fire	203					X													203
Protection from Air Pollution	214			X			X			X									214
				X						X									
Tree Improvem.	301				X														301
*Engineering	302																X		302
*Econ. of Timber	303															X			303
Farm Management	316															X			316
*Products	401															X	X	X	401
*Grades-Standards	512																X	X	512
*Marketing	502															X		X	502
*Supply, Demand Price	513															X			513
Competitive Relations	507															X			507
Asst. Abroad	603															X			603
Insects of Man	706							X											706
Pollut. Alleviation	901						X												901
*Recreation	902										X								902
*Multiple-Use	903										X				X	X			903
*Wildlife	904											X							904
*Trees for Environ.	905									X									905
Rural Income	907															X			

*Areas that are exclusively Forestry.

Table II. Research Problem Areas Keyed to the Goals of the National Program of Research for Forestry

RESEARCH PROBLEM AREAS	GOALS OF: A NATIONAL PROGRAM OF RESEARCH FOR FORESTRY
101 102 104 105 107 108 109 110 111 112	GOAL I To Insure a Stable and Productive Forest Economy for the Future Through Wise Management of Natural Resources.
201 202 203 214	GOAL II To Protect Forests From Fire, Insects, Diseases, and Other Hazards.
301 302 303 316	GOAL III To Produce an Adequate Supply of Forest Products at Decreasing Real Production Costs.
401	GOAL IV Improved Products and Processes and Enhancing Product Quality.
502 512 513 507	GOAL V To Improve Efficiency in the Marketing System.
603	GOAL VI To Assist Developing Nations.
706	GOAL VII To Protect the Well-Being of American People.
901 902 903 904 905 907	GOAL IX To Promote Community Improvement Including Development of Beauty, Recreation, Economic Opportunity, and Public Service.

Appendix

Index of Projects by States

State	Proj. No.	Abbreviated Title	Project Leader	Page
Alabama Auburn Univ.	901	Variation in Cell Anatomy.	J. F. Goggans	59
	902	Wood in Concrete.	E. J. Biblis	69
	903	Improved Forest Trees.	J. F. Goggans	59
	904	Woody Plants and Phytocides.	M. C. Carter	46
	905	Anatomy of Figured Wood.	H. O. Beals	59
	906	Use of Degraded Hardwoods.	T. C. Davis	70
	907	Fungal Pathogens of Pines.	W. D. Kelley	28
	908	Nursery Production of Hardwoods.	H. S. Larsen	46
	909	Forest Condition Classes.	E. W. Johnson	36
	910	Plastic-Overlaid Plywood.	E. J. Biblis	68
	911	Hypoxylon in Southern Oaks.	T. C. Davis	28
Alaska Univ. of	504	Nutrient Cycles.	K. Van Cleve	46
	541	Forest Soil Moisture.	B. J. Neiland	38
	7501	Integrated Forest Utilization.	M. R. Massie	75
Arizona Univ. of	620	Forest Recreation Demand.	D. A. King	86
	621	Fungi and Forest Vegetation.	R. L. Gilbertson	28
	631	Snow Water Yield.	D. B. Thorud	16
	636	Nitrogen and Carbon Balances.	J. O. Klemmedson	13
	662	Volume Tables; Ponderosa Pine.	G. S. Lehman	8
Arizona Northern Univ.	1	Stand Density Measures.	C. O. Minor	36
	2	Wood Quality and Growth.	G. Voorhies	72
	3	Vegetation and Climates.	D. W. Berry	9
	5	Range Forage on Parks.	L. D. Love	32
	6	Forest Recreation Resources.	L. D. Love	89
Arkansas Univ. of	610	Use Alternatives on Forests.	F. M. Meade	17
	611	Pine Sawflies.	L. O. Warren	22
	656	Bark Beetles and Fungi.	W. C. Yearian	22
	662	Pine Seed Production.	W. C. Yearian	20
	663	Forest-Tree Diseases.	C. L. Wilson	29
California Humboldt State College	3	Soil-Water-Vegetation.	D. J. Jader	11
	4	Productivity of Hardwoods.	H. V. Wiant	38
	5	Roosevelt Elk in Redwoods.	G. B. Donart	91
	6	Soil Moisture Drying Curves.	M. B. Rhea	38
	7	Recreation in Redwoods.	W. F. Murison	87
	8	Winter Recreation.	D. T. Jager	87
	9	Transpiration Reduction, Seedlings.	D. Thornburgh	59
	10	Pampas Grass; Redwood.	D. Thornburgh	47
	11	Provenance; Coast Redwood.	D. Thornburgh	59
	12	Regeneration of Redwood.	D. Thornburgh	47
	13	Undeveloped and Developed Land.	E. W. Pierson	14

State	Proj. No.	Abbreviated Title	Project Leader	Page
California Univ. of	2179	Ecological Potential.	E. C. Stone	46
	2180	Multiband Spectral Reconnaissance.	R. N. Colwell	7
	2181	Wood Machining.	J. D. Cumming	65
	2348	Microbiology and Pathology.	W. W. Wilcox	29
	2349	Optimum Forest Production.	D. E. Teeguarden	66
	2350	Long Range Timber Supply.	H. J. Vaux	75
	2351	Fuels on Wildlands.	A. M. Schultz	19
	2357	Marketability of Wood Products.	F. E. Dickinson	71
	2383	<i>Fomes Annosus</i> Root Rot.	F. W. Cobb	29
	2447	Thinning Regimes for Conifers.	R. F. Grah	67
	2495	Utilization of Bark.	A. B. Anderson	82
	2500	Range Plant Populations.	H. F. Heady	32
	2505	Markets for Timber.	H. J. Vaux	67
	2520	Simulation of Forests.	L. C. Wensel	36
	2538	Wood Procurement Systems.	W. McKillop	65
Colorado State Univ.	311	Genetic Potential.	G. H. Fechner	50
	312	Land Use and Water Quality.	J. R. Meiman	16
	313	Forest Recreation Resources.	A. T. Wilcox	89
	314	Particle Board.	D. L. Crews	82
	315	Ponderosa Pine, Bitterbrush.	H. W. Steinhoff	47
	316	Hydrology and Erosion.	W. D. Striffler	14
	317	Soil-Site; Lodgepole Pine.	E. W. Mogren	39
	318	Systemic Insecticides.	N. D. Wygant	22
Connecticut Univ. of	340	White-Tailed Deer.	R. D. McDowell	95
	376	Habitat of Cottontails.	R. D. McDowell	92
	390	Open-Space Planning.	M. J. Gratzner	11
Connecticut New Haven	405	Environment and Photosynthesis.	D. N. Moss	47
	408	Stomata — Closing Chemicals.	P. E. Waggoner	16
	411	Phosphorus in Lake Sediments.	R. D. Harter	11
	414	Analysis of Hardwood Forests.	D. B. Woods	34
	415	Waste Water Renovation.	D. E. Hill	13
Delaware Univ. of	715-E	Wild-Land; Urban Impact.	R. Jones	92
	759	Nutrition of Holly.	C. W. Dunham	59
Florida Univ. of	1032	Wildlife Using Sites.	S. L. Beckwith	92
	1130	Soil Survey Information.	W. L. Pritchett	47
	1210	Nutrition and Reproduction.	R. G. Stanley	59
	1250	Water Control; Forest Production.	W. L. Pritchett	59
	1293	Stock-Scion Relationships.	W. H. Smith	59
	1320	Fusiform Rust Resistance	R. A. Schmidt	25
	1344	Improvement of Sand Pine.	R. E. Goodard	47
Georgia Univ. of	11	Rabbit Population.	J. H. Jenkins	95
	12	Quail Population.	J. H. Jenkins	95
	14	Biosynthesis of Oleoresins.	C. L. Brown	51
	15	Exterior Building Components.	J. T. Rice	69
	16	Site-Growth; Tupelo.	J. T. May	47
	17	Growth and Wood Formation.	J. R. Beckwith	59
	18	Insects; Pine Cones and Seeds.	R. T. Franklin	22
	19	Cash Flow and Forest Management.	J. L. Clutter	67
	20	Contaminants in Animals.	J. H. Jenkins	95
	21	Growth and Yield.	J. L. Clutter	73
	22	Quick-Coppicing Hardwoods.	C. L. Brown	59

State	Proj. No.	Abbreviated Title	Project Leader	Page
Hawaii Univ. of	139	Fertilization and Culture.	Y. W. Tamimi	13
	140	Forest Floors and Soils.	L. D. Swindale	9
	715	<i>Phytophthora</i> in Soils.	E. E. Trujillo	29
Idaho Univ. of	1	Site and Productivity.	E. W. Tisdale	36
	2	Roots of Coniferous Seedlings.	H. Loewenstein	59
	3	Heritability and Population.	C. W. Wang	51
	4	Estimating Recreational Visits.	H. R. Alden	89
	7	Stress in Growth Rings.	A. D. Hofstrand	82
	8	Grain Angle and Strength.	J. P. Howe	82
	10	Elk and Cattle; Reforestation.	F. H. Pitkin	47
	11	Decay of Lumber Trees.	A. D. Partridge	29
	12	Livestock Trampling.	L. A. Sharp	32
	13	Cone and Seed Insects.	J. A. Schenk	22
Illinois Univ. of	303	Moisture; Tree Growth.	W. R. Boggess	59
	310	Wood-Using Industries.	I. I. Holland	71
	334	Penta-Treatment and Strength.	C. S. Walters	82
	360	Moisture Stress; Growth; Wood.	A. R. Gilmore	52
Illinois Southern Illinois Univ.	4-67	Dendrochronology.	W. C. Ashby	36
	CW-7-67	White-Tailed Deer.	W. D. Klimstra	95
	64-R-4	Hardwood Planting.	C. A. Budelsky	47
	65-R-9	Moisture in Wood.	A. A. Moslemi	76
	65-R-13	Forest Land Taxation.	R. I. Beazley	17
	66-R-26	Devils Kitchen Lake.	D. R. McCurdy	89
	67-5-14	Native Trees; Parks.	D. R. McCurdy	39
	67-R-1	Allocation of Resources.	R. I. Beazley	75
	67-R-23	Measuring Recreation Use.	D. R. McCurdy	89
Indiana Purdue Univ.	1269	Management Planning.	T. W. Beers	37
	1353	Design of Wood Rafters.	S. K. Suddarth	69
	1354	Outdoor Recreation Resources.	D. M. Knudson	17
	1476	Culture of Hardwoods.	W. R. Byrnes	60
	1477	Forest Ecosystems.	C. Merritt	37
	1586	Data Processing System.	J. W. Moser	39
Iowa State Univ.	1580	Forest-Recreation Investment.	H. H. Webster	89
	1582	Photosynthesis, Respiration.	G. Gatherum	60
	1650	Wood-Use Problems.	D. R. Prestemon	69
	1663	Fluid Behavior in Wood.	J. D. Wellons	76
	1744	Preferences for Housing.	D. R. Prestemon	69
Kansas State Univ.	668	Windbreak Influences.	W. A. Geyer	13
	670	Marketing of Forest Products.	W. A. Geyer	71
	671	Insects Attacking Trees.	H. E. Thompson	22
	672	Christmas Tree Production.	R. W. Funsch	47
	721	Strip Mined Lands.	W. A. Geyer	12
Kentucky Univ. of	194	Cation-Anion Uptake.	A. J. Hiatt	13
	1015	Use of Appalachian Lumber.	J. N. Walker	69
	1028	Wood Fiber Mechanics.	R. Mark	77
	1029	Composite Pole Laminates.	R. Mark	82

State	Proj. No.	Abbreviated Title	Project Leader	Page
Louisiana	1	Forestry Yield Data.	E. R. Andraulot	47
Polytechnic	2	Burning of Longleaf Pine.	P. B. Moseley	47
Institute	3	Bark as Soil Conditioner.	J. Wright	82
	4	Forest Soil Site Index.	C. G. Hobgood	47
	5	Pine-Oak Gall Rusts.	F. F. Jewell	26
	6	Workmen's Compensation and Safety.	E. J. Carothers	67
Louisiana	1177	Large Private Forest Owners.	R. W. McDermid	87
State	1232	Public Recreation.	R. W. McDermid	88
Univ.	1233	Lumber Distribution Patterns.	P. J. Fogg	71
	1237	Producing Christmas Trees.	B. H. Box	47
	1238	Woodrat in Hardwoods.	L. L. Glasgow	93
	1266	Competition, Pine Plantations.	T. D. Keister	47
	1276	Rooting Pine Trees.	N. E. Linnartz	47
	1356	Rabbits in Hardwood Forests.	F. W. Martin	95
	1440	Liquid and Gas Permeability.	E. T. Choong	82
	1444	Timber Harvesting Systems.	R. W. McDermid	65
Maine	5002	Growth of Forest Trees.	C. E. Schomaker	52
Univ. of	5003	Density and Seasoning.	N. P. Kutscha	82
	5004	Wood Properties and Grades.	J. E. Shottafer	69
	5005	Deer Upon Vegetation.	S. D. Schemnitz	93
	5006	Nutrients, Weight of Trees.	H. E. Young	60
	5007	Control of Gall Midge.	E. A. Osgood	22
Maryland	A-26	Forest Market Structure.	R. F. McDonald	71
Univ. of	H-83	Pine Cone Insects.	W. E. Bickley	20
	J-101	Seedlings, Soil Fungi	W. L. Klarman	29
	L-100	Propagation by Needle Fascicles.	J. B. Shanks	60
	T-16	Forest Recreation.	F. H. Forsyth	90
Massachusetts	1	Maple Tree Decline.	W. M. Banfield	26
Univ. of	2	Evapo-Transpiration, Drainage.	D. L. Mader	16
	3	Rheology of Wood.	R. B. Hoadley	82
	4	Wood Properties, Red Pine.	H. B. Gatslick	82
	5	Requirements of Grouse.	R. B. Brander	95
	6	Virus Diseases; Hardwoods.	G. N. Agrios	26
	7	<i>Lophodermium</i> Needle Cast.	W. M. Banfield	29
	8	Recreational Resources.	W. P. MacConnell	8
	9	Maple Tree Roots.	B. F. Wilson	60
Michigan	1	C-14; Phloem Transport.	R. Zahner	60
Univ. of	2	Beetles; Genus <i>Agrilus</i> .	F. B. Knight	21
	8	Biosystematics of Birch.	B. V. Barnes	60
	10	Carbohydrate Physiology.	R. Zahner	52
	12	Vessel Length in Angiosperms.	R. Zahner	60
	14	Population Regulation; Beetles.	F. B. Knight	22
	15	Preservative Treated Wood.	H. L. Morton	29
Michigan	936	Mineral Nutrition; Trees.	J. W. Hanover	60
State	942	Arthropod Component; Conifers.	J. A. Butcher	23
Univ.	978	Forest Management Opportunities.	V. J. Rudolph	40
	979	Nutrition of Seedlings.	G. Schneider	53
	980	Utilization and Marketing.	L. James	71
	982	Wildlife Food; Aesthetic Value.	L. W. Gysel	34
	984	High Quality Black Walnut.	D. P. White	47
	1029	Recreation Capacity; Small Lake.	M. Chubb	90

State	Proj. No.	Abbreviated Title	Project Leader	Page
Michigan Technological Univ.	4	Logging Survey.	V. G. Smith	65
	5	Skidding Time Analysis.	H. M. Steinhilb	65
	7	Soil-Site in Hardwoods.	S. G. Shetron	60
	3011	Genetic Improvement.	R. L. Sajdak	60
	3012	Automatic Data Processing.	J. W. Meteer	37
	3013	<i>Scleroderris</i> Canker.	N. F. Sloan	23
	3014	Deciduous Deeryard.	N. F. Sloan	95
	3015	Eastern Hemlock Reproduction.	P. S. Johnson	34
	3016	Recreational Opportunities.	C. R. Crowther	90
Minnesota Univ. of	17-85	Small Mammals; Reseeding.	J. R. Beer	47
	19-16	Red Pine Reproduction.	B. A. Brown	47
	19-18	Tubelings for Regeneration.	A. A. Alm	47
	19-38	Computer; Forest Management.	H. H. John	41
	19-43	Recreation; Land Management.	F. H. Kaufert	90
	19-55	Flexural Creep; Stress-Rupture.	J. G. Haygreen	82
	19-56	Freezing for Drying.	R. W. Erickson	82
	19-60	Acceptance of Aspen Studs.	R. D. Thompson	82
	19-77	Management of State Park.	H. L. Hansen	90
	19-78	Hybridization Studies.	S. S. Pauley	60
	19-79	Ecological Forest Production.	E. V. Bakuzis	42
	22-17	Ecology of Wood Decay.	D. W. French	29
	22-18	Dwarf Mistletoe.	D. W. French	29
Mississippi State Univ.	1120	Stem and Density of Pine.	R. D. Ross	42
	1122	Multinodal Growth Shoot Systems.	W. W. Elam	60
	1124	Retail Marketing; Softwood.	F. W. Taylor	73
	1128	Nutrient Cycle in Pine.	G. L. Switzer	53
	1129	Insects Attacking Trees.	W. W. Neel	23
	3621	Shrinkage of Pine.	J. Yao	83
	3622	Preservation; Poles and Piling.	W. S. Thompson	83
	3623	Wood Properties of Hardwoods.	W. S. Thompson	83
	3624	Efficiency; Lumber Manufacture.	W. S. Thompson	83
	3625	Wood Adhesives.	H. R. Rogers	83
	3626	Laminated Hardwood Lumber.	J. Yao	83
Missouri Univ. of	522	Energy and Water Balance.	G. S. Cox	11
	534	Artificial Pollination; Pines.	R. Polk	60
	535	Growth-Quality.	E. A. McGinnis	72
	540	<i>Fomes Annosus</i> .	M. J. Walterscheidt . . .	29
	543	Silvicultural Practices.	R. C. Smith	47
	606	Morphological Changes.	G. N. Brown	60
	607	Genetics; Forestation.	R. B. Polk	53
	617	Programs: Private Forestry.	J. M. Nichols	17
	625	Forest Ecological Data.	D. Duncan	37
Montana Univ. of	202	Marketing Montana Lumber.	R. M. Wambach	71
	205	Forest Property Taxing.	W. K. Gibson	17
	302	Burning; Timber Harvesting.	R. W. Steele	47
	401	Variability of Larch.	J. P. Krier	83
	603	Grazing Use; Forage Yield.	L. Eddleman	17
	804	Recreation on Forest Lands.	S. S. Frizzell	90
	904	Hybridization of Larch.	G. M. Blake	60
	1001	Soil Moisture; Forest Communities.	T. J. Nimlos	48
	1604	Spruce Budworm Defoliation.	J. H. Lowe	23

State	Proj. No.	Abbreviated Title	Project Leader	Page
Montana	1610	Photo-Interpretation.	W. R. Pierce	8
Univ. of	1801	Nutrient Culture of Larch.	M. J. Behan	60
(Cont.)	2001	Forest Resource Multiple Use.	W. K. Gibson	17
Nebraska	20-23	Windbreak Shelter Effects.	W. T. Bagley	12
Univ. of	20-28	Tree Breeding.	W. T. Bagley	60
Nevada	670	Evapotranspiration Patterns.	C. M. Skau	48
Univ. of	671	Establishing Jersey Pine.	C. M. Skau	48
	672	Recreational Uses.	P. T. Tueller	89
	674	Erosion-Control Planting.	C. M. Skau	42
New Hampshire	1	Balsam Fir Christmas Trees.	P. E. Bruns	60
Univ. of	2	Programming Models.	B. B. Foster	67
	3	Stress-Strain: Hardwoods.	J. L. Hill	78
	4	Ecology of Acarina.	R. M. Reeves	23
New Jersey	245	Red Oak; English Ivy.	C. E. Hess	60
Rutgers	256	Forest Land Resources.	R. F. West	17
Univ.				
New Mexico	1	Vegetation Changes; Range.	R. D. Pieper	33
State	2	Mule Deer Population.	J. E. Wood	95
Univ.	4	Seed and Cone Insects.	H. G. Kinzer	21
	5	Soil-Site Requirements.	A. G. Wollum	48
	6	Particleboard Industry.	J. R. Gray	83
	7	Ponderosa Pine Cone Beetle.	H. G. Kinzer	23
New York	901	Ectotrophic Mycorrhizae.	E. L. Stone	29
Cornell	902	Simulated Animal Damage.	L. S. Hamilton	95
Univ.	903	Suburban Forest Ownership.	L. S. Hamilton	90
	904	Wildlife Legislation, N.Y.	L. S. Hamilton	95
	905	Fertility; Ecology, Growth.	E. L. Stone	60
	906	Rural Land Classification.	L. S. Hamilton	8
	907	Vegetation for Wildlife.	J. W. Gaslick	95
	908	Absentee Forest Owners.	A. Dickson	14
New York	10-272A	Growth Studies.	H. B. Tepper	37
Syracuse	B	Potash Depleted Plantations.	C. DeZeeuw	60
College of	F	Wood Quality Variability.	W. T. Gladstone	60
Forestry	G	Arabinogalactan.	T. E. Timell	61
	H	Seed Dormancy.	E. Sondheimer	54
	I	Forest Sampling.	C. A. Bickford	37
	J	Deer Habitat Studies.	D. F. Behrend	48
	K	Aesthetics; Forests.	W. D. Wenger	71
	L	Chemistry; Aquatic Plants.	R. T. LaLonde	61
North	4002	Wood Property Variation.	R. L. McElwee	83
Carolina	4003	American Forest Policy.	J. O. Lammi	75
State Univ.	4004	Tree Stem Movement.	J. W. Duffield	61
	4005	Fiber Properties; Paper Quality.	E. L. Ellwood	83
	4006	Gas Phase Treatment.	A. J. Stamm	83
	4007	Systems Analysis.	D. Steensen	75
	4008	Sizing of Paper, Paperboard.	C. G. Landes	83
	4009	Mechanical Behavior of Wood.	J. Hsu	83

State	Proj. No.	Abbreviated Title	Project Leader	Page
North Carolina State Univ. (Cont.)	4010	Genotype Productivity.	T. O. Perry	54
	4011	Sweetgum Plantations.	J. W. Johnson	55
	4012	Forest Tree Diseases.	E. B. Cowling	29
	4013	Carolina Shagbark Hickory.	A. W. Cooper	37
	4014	Models of Tree Growth.	W. L. Hafley	37
	4015	Variability in Yellow-Poplar.	R. C. Kellison	35
	4016	Taxonomic Relationships.	L. C. Saylor	61
	4017	Pulp and Paper.	C. N. Rogers	65
	4018	Fertilization and Irrigation.	C. B. Davey	61
	4019	Fractionation of Cellulose.	W. Brown	83
	4020	Forest Wildlife.	F. S. Barkalow	95
North Dakota State Univ.	12-1	Shelter Belts.	E. P. Lana	12
Ohio, OARDC Wooster	1	Fertilizer Effects.	J. P. Vimmerstedt	61
	2	Seed Development.	H. B. Kriebel	61
	3	Control of Insects.	R. L. Campbell	23
	5	Juvenile Growth.	A. R. Vogt	56
	6	Physiology of Wood.	F. W. Whitmore	61
Oklahoma State Univ.	1234	Pot Tests; Selected Trees.	T. Q. Lind	61
	1235	Nantucket Pine Tip Moth.	R. D. Eikenbary	23
	1236	Aerial Volume Tables.	D. W. Robinson	36
	1237	Mortality in Timber.	T. H. Silker	48
	1241	Clinal Variation.	C. E. Posey	56
	1246	Wood Properties.	C. E. Posey	83
	1247	Tree Distribution.	N. Walker	48
	1304	Improved Pine.	C. E. Posey	57
	1332	Movement of Herbicides.	E. Basler	61
	1348	Pine Hybrids.	C. E. Posey	61
	1349	Cottonwood Improvement.	C. E. Posey	61
	1360	Undesirable Woody Plants.	T. H. Silker	48
Oregon State Univ.	F600	Survival Under Drought.	D. P. Lavender	48
	F646	Forest Land Management.	R. H. Waring	48
	F647	Compounds from Bark.	H. Aft	79
	F759	Family Variation.	H. Irgens	61
	F760	Douglas-Fir Seed.	W. P. Wheeler	61
	F761	Mechanisms of Succession.	M. Newton	48
	F762	Flower Induction.	K. K. Ching	61
	F763	Western Hemlock.	R. T. Lin	83
	F786	Variation in Bark.	R. L. Krahmer	61
	F794	Transpiration of Seedlings.	W. K. Ferrell	61
	F812	Electrical Properties of Wood.	R. T. Lin	79
	F819	<i>Phytophthora</i> Root Rot.	L. F. Roth	29
	F822	Volume by Height Accumulation.	D. P. Paine	37
	F823	Spatial Distribution; Variance.	D. P. Paine	37
	F824	Hemlock <i>Hylesinus</i> .	W. P. Nagel	23
	F825	Factors on Pulping.	W. J. Bublitiz	83
	F833	Chemical Brush Control.	C. F. Sutherland	48
	F840	Red Alder Ecosystems.	J. Zavitzkovski	48
	F841	Three-P Sampling; Growth.	J. F. Bell	37
	F843	Growth and Yield; Douglas-Fir.	D. P. Paine	8

State	Proj. No.	Abbreviated Title	Project Leader	Page
Pennsylvania State Univ.	1487	Timber, Wildlife Food.	W. W. Ward	61
	1488	Annual Canker of Maple.	W. W. Ward	29
	1489	Rheology of Cellulose.	W. K. Murphey	80
	1492	Kerfless Cutting.	W. K. Murphey	83
	1493	Soil-Site Evaluation.	W. W. Ward	48
	1494	Wildland Recreational Management.	J. L. George	90
	1495	Timber Harvesting Methods.	W. E. Sopper	16
	1625	Systems Analysis.	P. C. Kersavage	75
	1702	Forest Tree Diseases.	F. A. Wood	27
	1745	Revegetation: Coal Mining.	R. J. Hutnik	48
	1750	Gall Aphid; Control.	W. H. Kearby	23
	1805	Stochastic Models; Simulation.	P. E. Dress	61
	1781	Knife Variables; Slicing.	W. K. Murphey	83
Puerto Rico Univ. of	1	Diseases of Forest Trees.	J. H. Lopez-Rosa	29
	2	Cedar Shoot-Borer.	L. F. Martorell	22
	3	Control of Termites.	L. F. Martorell	23
Rhode Island Univ. of	125	Development of Forested Land.	C. Gratto	17
	953	Deer; Forest Alteration.	J. J. Kupa	95
	954	Evapotranspiration Losses.	J. H. Brown	44
South Carolina Clemson Univ.	704	Genetics of Trees.	R. E. Schoenike	58
	705	Inbreeding in Pine.	R. E. Schoenike	61
	706	Harvest; Maximize Returns.	J. R. Warner	44
	707	Logging Cost Studies.	W. A. Shain	65
	708	Moisture; Photosynthesis.	W. H. D. McGregor . . .	61
	709	Seed Embryos.	W. H. D. McGregor . . .	62
	717	Tree Improvement Studies.	R. E. Schoenike	62
	789	Irrigation and Fertilization.	W. H. D. McGregor . . .	62
	853	Gas Exchange; Pine Needles.	R. M. Allen	62
	881	Variation and Inheritance.	O. B. Garrison	62
South Dakota State Univ.	420	Tree Planting; Recreation.	E. Collins	90
	452	Grasslands.	J. T. Nichols	48
	475	Selection and Propagation.	D. E. Herman	46
Tennessee Univ. of	1	Mixed Species Plantations.	E. Thor	48
	2	Fertilizers and Irrigation.	E. R. Buckner	62
	3	Quail Management.	R. W. Dimmick	94
	4	Forest Management Determinants.	G. R. Wells	48
	5	Recreation Resources, Private.	K. F. Schell	90
	6	Wood Duck Ecology.	R. W. Dimmick	96
	7	Blight; American Chestnut.	E. Thor	29
	8	Christmas Tree Breeding.	E. Thor	71
	9	Hardwood Characteristics.	H. A. Core	83
	10	Timber-Growing Practices.	G. R. Wells	17
Texas A&M Univ.	1524	Distribution of Wood Products.	H. B. Sorenson	72
	1525	Southern Pine Beetle.	P. L. Adkisson	23
	1526	Live Oak Decline.	E. P. Van Arsdel	28
	1527	Development of Loblolly Pine.	R. R. Rhodes	62
	1649	Water Stress and Growth.	D. M. Moehring	62
	1650	The Formosan Termite.	A. E. Lund	23
	1673	Intensive Culture; Hardwoods.	R. G. Merrifield	48

State	Proj. No.	Abbreviated Title	Project Leader	Page
Utah State Univ.	641	Manage for Water Yield.	J. D. Schultz	16
	658	Essential Oils.	W. H. Johnson	62
	669	Predicting Campground Use.	R. S. Whaley	90
	670	Foliage Removal Effects.	G. B. Coltharp	13
	733	Reduction of Streamflow Data.	G. E. Hart	15
	739	Cooperation for Recreation Area.	R. A. Ogle	89
	757	Conifer Distribution.	R. M. Lanner	37
	767	Lumber Manufacture in Utah.	A. B. Furniss	83
Vermont Univ. of	1	Christmas Tree Culture.	M. L. McCormack	72
	2	Leader Damage, Growth; Conifern.	T. L. Turner	48
	4	Volume Equations.	L. E. Zai	37
	6	Multiple Use; Forested Land.	F. O. Sargent	18
	7	Wood Ducks.	R. W. Fuller	96
	8	Wood Quality of Birch.	P. R. Hannah	73
	9	Light and Internal Moisture.	B. W. Post	62
	10	Chemical Weed Suppression.	T. R. Flanagan	48
	11	Sap Flow in Sugar Maples.	J. W. Marvin	58
	12	Cell Transitions; Hardwoods.	J. W. Marvin	62
Virginia Polytechnic Institute	14	Management by Programming.	F. Armstrong	67
	11	Economic Model; Forest Regulations.	E. F. Thompson	75
	21	Seasoning of Large-Dimension.	R. E. Martin	80
	31	Parameters of Site.	H. Madgwick	62
	41	Oak-History; Deer Browse.	B. S. McGinnis	96
	51	Growth of Mixed Hardwoods.	J. P. Barrett	46
	61	Resource Use; Southeast.	D. P. Richards	48
	71	Reproductive Function, Deer.	R. L. Kirkpatrick	96
Washington State Univ.	81	Synthesis of Ribonucleic Acid.	R. E. Adams	62
	1770	<i>Hypoxylon Fuscum</i> in Alder.	J. D. Rogers	28
	1771	Genetics of Multinodalness.	R. M. Dingle	48
	1772	Piezoelectric Effect in Wood.	W. L. Galligan	83
	1775	Moisture Relationships.	M. D. Strickler	84
	1848	Guidelines for Recreation.	M. M. Mosher	18
	1849	Snow Catch in Crowns.	D. R. Satterlund	16
	1913	Watershed, Tractor Skidding.	D. D. Satterlund	15
	1925	Characteristics of Elk Sedge.	B. F. Roche	13
	1929	Vibration Structural Lumber.	R. F. Pellerin	73
Washington Univ. of	1942	Structure, Shear Strength.	A. F. Noskowiak	84
	1	Nitrogen; Growth.	S. P. Gessel	62
	3	Recreational Land Uses.	G. W. Sharpe	18
	4	Environment; Quality of Wood.	J. S. Bethel	73
	6	Ecology and Physiology.	D. R. M. Scott	48
	7	Harvesting; Second Growth.	G. Stenzel	65
	8	Fomes Annosus; Management.	C. H. Driver	29
	9	Surface Properties; Wood.	B. S. Bryant	69
	10	Anatomy and Processing.	L. Leney	83
	11	Water Retention; Foliage.	S. P. Gessell	16
	12	Fire, Forest Soil.	D. W. Cole	13
	13	Mathematics; Fiber Assemblages.	G. G. Allan	81
	15	Problems in Elasticity.	B. A. Jayne	82
	16	Genetic Studies; Hardwoods.	R. F. Stettler	62
	17	Forest Soils.	F. C. Ugolini	13

State	Proj. No.	Abbreviated Title	Project Leader	Page
Washington Univ. of (Cont.)	18	Biosynthesis of Maltol.	B. F. Hrutfiord	62
	19	Forest Products Industries.	T. Waggener	75
	20	Snow-Melt Water.	S. P. Gessel	16
	21	A Coniferous Ecosystem.	D. W. Cole	18
West Virginia University	1	Selection, Valuable Hardwoods.	F. C. Cech	59
	2	Growth and Density.	J. R. Hamilton	84
	3	Sprout Black Cherry.	C. B. Koch	84
	4	Lumber Handling Methods.	D. F. White	84
	5	Growth and Yield.	D. L. Kulow	48
Wisconsin Univ. of	1262	Genetics; Trees.	D. T. Lester	62
	1263	Population Dynamics; Sawflies.	D. M. Benjamin	23
	1264	Oak Wilt.	J. E. Kuntz	29
	1350	Metabolic Antitranspirants.	T. T. Kozlowski	62
	1364	Change in Forest Industries.	W. R. Bentley	74
	1434	Plantation Root Diseases.	R. F. Patton	29
	1518	Checks in Wood.	H. J. Kubler	73
	1571	Sampling Designs; Management.	L. J. Arvanitis	18
Wyoming Univ. of	879	Forest Margins.	M. May	33
	880	Biotic Communities.	H. G. Fisser	46
	928	Diseases of Aspen.	E. A. Andrews	29
	940	Ecology of Aspen.	A. A. Beetle	48

Table III. Summary of McIntire-Stennis Forestry Research Project Activity during 1968

Institutions	Program Elements Remote Sensing 624	Soil & Water 685	Watershed 687	Forest Fire 689	Insect & Disease 691	Range 612	Timber Production 693	Housing 669	Marketing 695	Products 697	Recreation 698	Wildlife 699	Total Number of Projects	Graduate Students	Publications	Scientists
Alabama, Auburn Univ.	-	-	-	-	2	-	6	2	1	-	-	-	11	6	2	9
Alaska, Univ. of	-	-	-	-	-	-	2	-	1	-	1	-	4	1	0	4
Arizona, Univ. of	1	1	1	-	-	-	-	-	-	-	-	-	4	6	3	4
Arizona, Northern Univ. of	-	1	-	-	1	1	1	-	1	-	1	-	6	3	1	5
Arkansas, Univ. of	-	-	1	-	4	-	-	-	-	-	-	-	5	8	6	5
California, Univ. of	1	-	-	1	2	1	7	-	4	-	-	-	16	26	13	14
California, Humboldt St.	-	2	-	-	-	-	6	-	-	-	2	-	10	7	6	8
Colorado State Univ.	-	-	2	-	1	-	3	-	-	-	1	-	7	8	3	10
Connecticut, Univ. of	-	1	-	-	-	-	-	-	-	-	-	3	4	0	0	2
Conn. Ag. Exp. Sta.	-	2	1	-	-	-	2	-	-	-	-	-	5	0	10	5
Delaware, Univ. of	-	-	-	-	-	-	1	-	-	-	-	1	2	0	3	2
Florida, Univ. of	-	-	-	-	1	-	5	-	-	-	-	1	7	3	1	9
Georgia, Univ. of	-	-	-	-	1	-	7	1	1	1	-	-	11	19	16	9
Hawaii, Univ. of	-	2	-	-	1	-	-	-	-	-	-	-	3	1	0	4
Idaho, Univ. of	-	-	-	-	2	1	4	-	1	2	1	1	12	7	2	13
Illinois, Univ. of	-	-	-	-	-	-	2	-	1	1	-	-	4	10	1	4
Illinois, S.I.U.	-	-	1	-	-	-	3	-	1	2	4	1	12	15	7	7
Indiana, Purdue Univ.	-	-	1	-	-	-	6	1	-	1	-	-	9	0	5	6
Iowa State Univ.	-	-	-	-	-	-	1	1	-	2	1	-	5	9	2	7
Kansas State Univ.	-	2	-	-	1	-	1	-	1	-	-	-	5	3	3	3
Kentucky, Univ. of	-	1	-	-	-	-	-	1	-	2	-	-	4	4	5	4
Louisiana State Univ.	-	-	-	-	-	-	4	-	1	1	2	2	10	3	9	10
Louisiana Tech.	-	-	-	-	1	-	4	-	-	1	-	-	6	4	3	8
Maine, Univ. of	-	-	-	-	1	-	2	1	-	1	-	1	6	7	15	9
Maryland, Univ. of	-	-	-	-	2	-	1	-	1	-	1	-	5	6	1	6
Massachusetts, Univ. of	1	-	1	-	3	-	1	-	-	2	-	1	3	12	2	8
Michigan, Univ. of	-	-	-	-	3	-	4	-	-	-	1	-	8	4	6	5
Michigan State Univ.	-	-	-	-	1	-	5	-	1	-	1	-	8	16	10	8
Michigan Tech.	-	-	-	-	1	-	6	-	-	-	1	1	9	6	1	8
Minnesota, Univ. of	-	-	-	-	2	-	5	-	-	3	2	-	12	15	14	13
Mississippi State Univ.	-	-	-	-	1	-	3	-	1	6	-	-	11	4	8	10
Missouri, Univ. of	-	1	1	-	1	-	5	-	1	-	-	-	9	19	7	10
Montana, Univ. of	1	-	3	-	1	-	4	-	1	1	1	-	12	17	12	14
Nebraska, Univ. of	-	1	-	-	-	-	1	-	-	-	-	-	2	2	1	2
Nevada, Univ. of	-	-	-	-	-	-	3	-	-	-	1	-	4	2	1	5
New Hampshire, Univ. of	-	-	-	-	1	-	2	-	-	1	-	-	4	2	1	4
New Jersey - Rutgers	-	-	1	-	-	-	1	-	-	-	-	-	2	4	1	3
New Mexico State Univ.	-	-	-	-	2	1	1	-	-	1	-	1	6	2	2	6
N.Y., Cornell Univ.	1	1	-	-	1	-	1	-	-	-	1	3	8	4	7	8
N.Y., SUNY, Syracuse	-	-	-	-	-	-	8	-	1	-	-	-	9	10	12	12
North Carolina St. Univ.	-	-	-	-	1	-	9	-	2	6	-	1	19	28	14	24
North Dakota St. Univ.	-	1	-	-	-	-	-	-	-	-	-	-	1	3	1	1
Ohio, OARDC, Wooster	-	-	-	-	1	-	4	-	-	-	-	-	5	2	2	5
Oklahoma State Univ.	-	-	-	-	1	-	10	-	-	1	-	-	12	3	6	7
Oregon State Univ.	1	-	-	-	2	-	13	-	-	4	-	-	20	19	6	20
Pennsylvania State Univ.	-	-	1	-	3	-	4	-	1	4	1	-	14	15	24	14
Puerto Rico, Univ. of	-	-	-	-	3	-	-	-	-	-	-	-	-	0	0	2
Rhode Island, Univ. of	-	-	1	-	-	-	1	-	-	-	-	1	3	4	3	3
S.C., Clemson Univ.	-	-	-	-	-	-	10	-	-	1	-	-	11	3	0	6
South Dakota St. Univ.	-	-	-	-	-	-	2	-	-	-	1	-	3	0	2	3
Tennessee, Univ. of	-	-	1	-	1	-	3	-	1	1	1	2	10	7	3	6
Texas A & M Univ.	-	-	-	-	3	-	3	-	1	-	-	-	7	3	2	7
Utah State Univ.	-	1	2	-	-	-	2	-	-	1	2	-	8	11	4	11
Vermont, Univ. of	-	-	1	-	-	-	7	-	4	-	-	1	13	3	2	11
Virginia Tech.	-	-	-	-	-	-	4	-	1	1	-	2	8	13	11	11
Washington, Univ. of	-	2	4	-	1	-	5	1	2	4	-	-	19	27	10	18
Wash. State Univ.	-	1	3	-	2	-	1	-	1	3	-	-	11	3	2	9
West Virginia Univ.	-	-	-	-	-	-	2	-	-	3	-	-	5	11	2	5
Wisconsin, Univ. of	-	-	1	-	3	-	2	-	2	-	-	-	8	8	22	10
Wyoming, Univ. of	-	-	-	-	1	1	2	-	-	-	-	-	4	4	0	5
Totals	6	20	27	1	59	5	202	8	34	56	28	23	469	442	318	462



